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A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

The Proposed Program of Bud Selection Work.

We now have at hand information and evidence that convince us that the yields of the cane fields in these Islands can be increased by selecting and propagating the superior strains of our leading sugar cane varieties.

The benefit which is to come from this can be greatly expedited if the industry will set a goal for itself and make plans to reach that goal by a given time.

We believe that it is entirely practicable for the plantations of this Association to decide now that *all cane planted in 1924 will be from nurseries of selected cane.*

Within the next twelve months our representatives can work with each plantation in selecting and planting out a mother field of from two to ten acres, say five acres on an average to a plantation. Five acres on forty plantations make two hundred acres of nursery land. A year later this cane can be handled in two ways:

1. Make a re-selection to find the very best strains.
2. Spread any and all of it that is superior to the general run of the plantation as rapidly as possible. Perhaps half of the mother field can be discarded to advantage. The balance planted with ample spacing can serve to extend the two hundred acres to four thousand in 1923. This will provide all the seed cane the industry will be prepared to plant in 1924.

While this will mean much to the plantations, it does not indicate the final aim of bud selection work. It serves to help the plantations while the project is continued in the search and propagation of those strains of cane of outstanding superiority. Once we have large fields planted in the way we have described, the work of finding the very best strains will be greatly facilitated.

All plantations desiring to cooperate with the Experiment Station along these lines should notify us far enough in advance to be included in the program of work that is being arranged.

The Fern Weevil Parasite.

Its Life History and Introduction to Hawaii.

By C. E. Pemberton.

Since the first appearance of the destructive Australian fern weevil *Syagrius fulvitarsis* Pasc. in the Hawaiian Islands, and its subsequent spread during recent years into the beautiful fern forests near Kilauea on the Island of Hawaii, much discussion has occurred respecting its possible origin. D. T. Fullaway, in a paper on the life-history of the weevil,[1] concludes that it is of Australian origin, since it has been recorded only from that country, together with another related species, *Neosyagrius cordipennis* Lea, taken by W. W. Froggatt in the Botanic Gardens in Sydney. Another species, *Syagrius intrudens* Waterhouse, was collected in the Botanic Gardens of Dublin, Ireland, in 1902. The following facts would rather prove his contention to be correct.

Material of *fulvitarsis* was originally collected by French of the Melbourne Botanic Gardens, in 1857, and given the label Wien Wien, Richmond River, New South Wales. No additional data were included. W. W. Froggatt later found it abundantly infesting ferns in greenhouses and adjacent fern plots in the Botanic Gardens in Sydney.

With the object of locating the weevil, if possible, in its native habitat, in order to investigate its natural enemies, if present, a visit was made to the Richmond River in northern New South Wales in April, 1921. After considerable search, the weevil was finally located on ferns in a heavily forested country near the town of Dunoon, in the district of Whian Whian. This was no doubt the territory called Wien Wien by French in 1857. The weevil was also found at Lismore, in an uncut forest reserve, some 15 miles from Dunoon, then at Nimbin, a small town near the headwaters of the Richmond River; and in June, at the suggestion of Mr. Froggatt, a search was made in the virgin forests near Bulli, New South Wales, about 500 miles south of the Richmond River, and it was found there also.

At Nimbin, conditions for the search for parasites were most suitable, the town being close to an extensive mountainous district densely covered with great virgin forests. Here the parasite *Ischiogonus syagrii* was finally found. It was bred from larvae of the weevil taken in the native forests all about the town, and two months later the same wasp was found highly parasitizing the weevil at Bulli. The beetle, its larvae, and the parasite were found in forests untouched by man and remote from farmhouses, roads, or logging trails. This was fair proof of the nativity of *Syagrius*. Additional and yet more conclusive evidence, however, was obtained upon finding another weevil on ferns here, which, according to A. M. Lea of the Adelaide Museum, is a distinct and hitherto undescribed species of *Syagrius*. Nowhere were either of the weevils found abundant enough to interfere with the growth of even the tenderest of ferns. A large number of

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[1] The fern weevil *Syagrius fulvitarsis* Pasc. D. T. Fullaway. Hawaiian Forester and Agriculturist, Vol. XVIII, 5, pp. 101–114. 1 plate. May, 1921.

different species of ferns flourish in New South Wales and the weevil was ultimately taken from every species examined, including tree ferns and a common, coarse bracken. It was most readily found on the softer species. Yet in all the forest regions visited the beetle was comparatively rare. On some days, during the search for parasites, not more than a half-dozen weevils or larvae were found, and occasionally a full day's work brought nothing. This indicates the extent to which the insect is under natural control.

In spite of this scarcity of the weevil, the parasite *Ischiogonus* was practically always with it and maintainlng a parasitism estimated at close to sixty per cent.

In addition to the parasite *Ischiogonus syagrii,* a few individuals of another parasite, also found on the weevil-larvae, were bred. P. H. Timberlake has placed these in the genus *Eupelmus,* and concludes that it is probably a primary parasite also. The habits of this species were not investigated.

As noted above, *Ischiogonus* is a larval parasite. In order to ship it in quantity to Honolulu, larvae of the weevil, bearing eggs or larvae of the parasite thereon, were collected as rapidly as they could be found and placed, usually separately, in small glass vials plugged with a cotton stopper. The *Ischiogonus* larvae spun perfect silken cocoons in the vials after consuming the weevil-larvae. These vials were then taken to Sydney, some four hundred miles south, on two separate occasions. The first lot was placed on the steamship *Makura* on May 4th, 1921, and the second lot on the *Ventura* on May 31st. In both cases portions of each lot were placed in the ship's fruit or vegetable compartment, wherein a temperature of about 45° F. is constantly maintained. The other portions were kept at normal temperatures. In each case both portions of both shipments reached Honolulu in a satisfactory condition, and a total of 319 parasites ultimately hatched out, with both sexes well represented. Messrs. Muir and Fullaway liberated the first lot among weevil-infested ferns on Mt. Tantalus, back of Honolulu. The second lot was variously distributed on the Islands of Oahu and Hawaii by Mr. Fullaway. A few months after the first lot was set free he found parasitized weevil-larvae in the vicinity of the point of liberation, thus showing that the parasite will very probably establish itself in Hawaii.

The following is presented to indicate briefly the development and habits of this parasite:

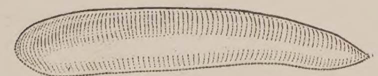


Fig. 1—Egg of *Ichiogonus syagrii.*

The Egg—The egg, when first laid, is .7 mm. long, less than a fifth as wide, smoothly surfaced, pearly white, rounded at one end, bluntly pointed at the other and slightly curved, giving one side a faintly concave outline, as shown in Fig. 1. Upon maturing it becomes pale-yellow and is a little broader than when first deposited. It is placed loosely upon the surface of the host-larva and may be found at any portion of the body, but most often on the cephalic half, as shown in Fig. 2, near the head of the *Syagris* larva. Eggs have been occasionally found within the fern stem lying free from the larva, but very close to it. These hatch normally and the parasitic larvae reach the host without apparent difficulty. As the eggs are not cemented on, nor inserted into the tissues of the *Syagrius* larva, it is quite possible that they occasionally become brushed off of its body by its sub-

sequent slight movements in the fern stem following parasitization. From one to four eggs are generally placed on a single larva. These all hatch normally, and if the host is a fairly large individual, these will all ultimately mature to average sized parasites. Exceptional cases have been observed in which as many as six eggs occurred on a single larva. These are deposited singly by one or more females.

Fig. 2—Mature *Syagrius* larva, showing two *Ischigonus* larvae feeding upon it and one *Ischiogonus* egg in natural position.

The duration of the egg stage was determined only during the early winter months in New South Wales. It varied from six to seven days, the temperature ranging between 48° and 65° F. In the forest summer temperatures in Hawaii this period will no doubt be much shorter.

The Larva — Upon hatching, the larva is a pale white, almost transparent, less than 1 mm. in length, showing fourteen distinct body-segments, including the head, and bearing a well-defined, open, tracheal system. It possesses a pair of short, sharply-curved acutely-pointed and exceedingly minute mandibles, indicating a faint brownish chitinization near the tips. The larva is capable of considerable movement, though it moves very slowly. It lies during the complete development on the surface of the weevil-larva, imperceptibly puncturing the skin and sucking the body juices. The growth is very rapid and within a few days the larva has doubled in size. The exact number of molts was not determined. There would appear to be at least three. As growth continues, a minute pair of antennal processes become visible near the front of the head, as shown in Fig. 3a. The mandibles, though changing little in size or shape, become more heavily chitinized, resembling those shown in Fig. 3b, greatly enlarged. The antennal processes are easily visible in the mature larva, their function being unknown. The larvae usually lie almost motionless upon the surface of the host. The body may occasionally bend slightly to right or left or move forward faintly. A *Syagrius* larva, if removed from a fern-stem following a recent parasitic attack, will frequently resemble that shown in Fig. 2. One or more glistening, pale-white larvae may be seen feeding upon its body, and sometimes an unhatched egg is present with them.

At maturity the *Ischiogonus* larva is much the same in general appearance as when first hatched. It has, however, increased greatly in size and can move about much more actively. Still the movement is sluggish. It usually varies from 3 to 5.5 mm. in length, depending upon the amount of food available for it. If one has developed singly upon a large *Syagrius* larva, it will be correspondingly large. If, however, there have been four or five developing together on the same host, the quantity of food will not have been so great and all may reach maturity at somewhat less than 3 mm. in length. The full-grown larva is covered

with fine, short, sharp spines, broad at the base, translucent, and occurring only on the first to the twelfth body-segments back of the head, they being especially numerous on the first segment. The dorsum of the fifth to the ninth segments, inclusive, is somewhat protuberent, as shown in Fig. 4. These characters are not visible in the immature larval stages.

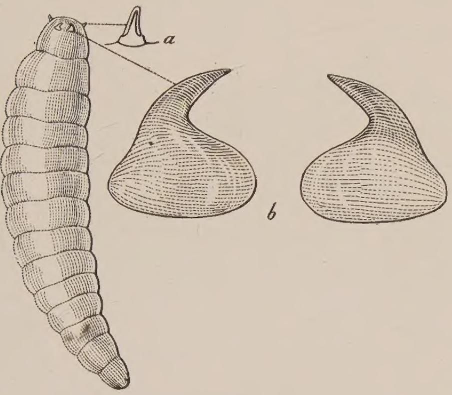


Fig. 3—Well-grown *Ischiogonus* larva, ventral view, showing (a) antennal process greatly enlarged, and (b) mandibles, also greatly enlarged.

With the growth of an *Ichiogonus* larva on the surface of the *Syagrius* larva, the latter shrinks, slightly at first, but more rapidly as the fluids are extracted and the parasite increases in size. It finally collapses entirely and assumes an appearance somewhat like that shown in Fig. 4. Hardly anything remains but the wrinkled integument and the hard, brownish head, and in the midst of these remains lies the glistening, fully-engorged *Ischiogonus* larva, ready to creep away a short distance in the hollow stem and spin its cocoon.

During the winter months in New South Wales, the active larval stage was found to occupy from nine to eleven days, this occurring at temperatures ranging between 48° and 70° F. This is a very rapid development, considering the temperature.

The Cocoon and Pupa—Upon reaching full growth, the *Ischigonus* larva, as above stated, usually moves away from the remains of the dead *Syagrius* larva, which it has fed upon and destroyed. It often crawls from one to one and one-half inches along the channel in the fern stem originally made by the weevil-larva. Here is slowly spins around its body a white, silken cocoon. This requires, in the winter temperatures of New South Wales, from 24 to 48 hours. The cocoon usually varies from 4.7 to 6.5 mm. in length, depending upon the size of the larva spinning it, and from 1.2 to 1.8 mm. in diameter. It is cylindrical, and bluntly closed at each end, as shown in Fig. 5. When several larvae mature on the same host their cocoons may frequently be found in an almost continuous chain in the fern - steam, but sometimes they may overlap or even lie side by side. At the temperatures above referred to, a considerable period

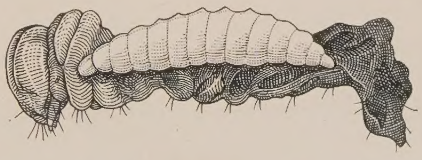


Fig. 4—Partly consumed *Syagrius* larva, upon which is a mature *Ischiogonus* larva.

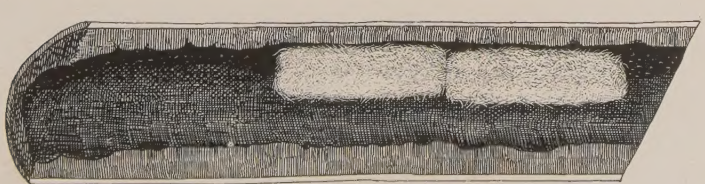


Fig. 5—Section lengthwise through fern stem, showing two *Ischiogonus* cocoons in natural position.

elapses between the apparent completion of the cocoon and pupation. All larvae under observation finally pupated from seven to eight days after the cocoon was constructed. The larvae could be daily observed within the delicate cocoons by examination under direct sunlight. The time required for spinning the cocoon and the prepupal period passed therein was the same for large, well-nourished larvae as for the very small, poorly-fed individuals.

Pupation was readily observed without cutting open the cocoons. At the same temperatures, the pupal stage was found to cover from eighteen to nineteen days. Under Honolulu temperatures it will be much shorter.

The Adult—The adult wasp emerges by gnawing open one end of the cocoon. If the end of another cocoon lies directly in front and against it and still contains a pupa, the adult bites its way through the side of its own cocoon, near the end. If the cocoon in front of it is empty, the adult from it having already passed out, the wasp cuts through the end of its own cocoon, through the back end of the one in front of it, and crawls through the latter to emerge. Sometimes from three to five such cocoons will be in a row and the wasp from each will ultimately pass out through the outer end of the last cocoon. Once into the hollowed fern-channel the parasite cuts a clean, somewhat circular hole directly through the wall of the fern-stem and escapes.

Mating may occur immediately after emergence, and oviposition has been noted four days later, in cool temperatures. Mature eggs were not found in quantity at any time within the egg-tubes of females, either freshly emerged or several weeks old. At the time of hatching not more than two mature eggs have been found in a female, and the greatest number of well-developed eggs ever dissected from any female, irrespective of age, was twelve. This indicates a rather slow rate of oviposition. The adult, however, is very hardy and long-lived. Of twelve adults kept in glass tubes and given neither food nor water, two lived for eighteen days, one for sixteen days, three for eleven days, and the remainder for from seven to nine days. When fed regularly on a solution of raw sugar and water, the adult can be kept alive for long periods, the males succumbing first. Of eighteen females and eight males, kept in such a manner, in an ordinary test-tube, indoors, at New South Wales winter temperatures, seven males lived from forty-eight to seventy-seven days, one male lived eighty-two days, and all of the females,

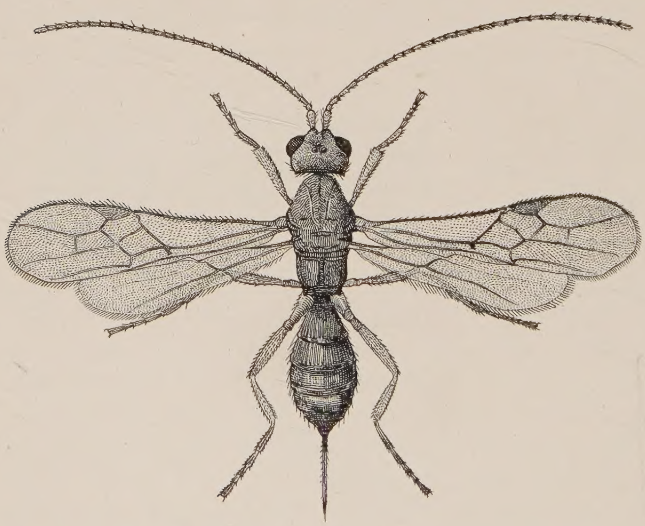


Fig. 6—Adult female *Ichiogonus syagrii*.

but one, are at the present writing still actively alive and ninety-one days old. They have had no opportunity to oviposit. If such had been the case is is hardly probable that they would all still be living.

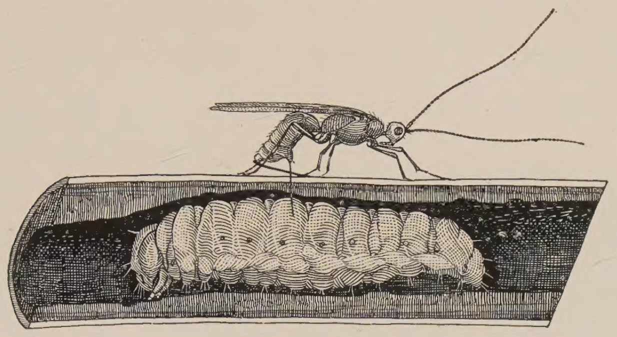


Fig. 7—Section lengthwise through fern stem to show *Ischiogonus* female ovipositing on *Syagrius* larva.

The female has no apparent difficulty in locating weevil-infested fern-stems. In moving about on a fern, the female will pause upon a spot beneath which lies a weevil larva, and after some hesitation and curious maneuvering, occupying sometimes a minute or more, will bring the tip of the ovipositor against the stem and gradually force the sharp ovipositor-blades through the tissue and into the larva, the sheadth not penetrating the fern but extending forward beneath her body and acting somewhat as a guide for the flexible blades. This process may occupy fifteen minutes or more, depending upon the toughness of the stem. Individuals have been timed for twenty minutes before the piercing of the fern and the placing of a single egg had been completed. The stinging of the larva evidently partially paralyzes it, and this effect is permanent, for it remains almost totally immobile thereafter. The general position of the female, when the ovipositor is fully inserted into the stem and against the larva, is shown in Fig. 7. Before removing the ovipositor, a single egg is deposited upon the surface of the larva. Sometimes larvae are stung but no egg is deposited. They have frequently been found in a semi-paralyzed condition without eggs or parasitic larvae thereon or near them in the stem. Usually well-grown larvae only are parasitized, but occasionally half-grown individuals have been found, bearing from one to four *Ischiogonus* eggs or larvae. In such cases the parasites may mature, but are very diminutive, owing to the absence of sufficient food. Such adults have been reared which were only 2.3 mm. in length. With abundance of food, a larva may develop to an adult sometimes 5.5 mm. in length. Females will oviposit on the same larva more than once, and no doubt different females will attack the same larva successively. This accounts for the presence of *Syagrius* larvae bearing *Ischiogonus* eggs and immature larvae at the same time, showing that eggs had been deposited at different intervals.

The complete life-cycle of *Ischiogonus,* under the fairly cold winter conditions of New South Wales, was found to require about forty-four days. This cycle in Hawaii during winter will probably be even less, and much shorter in summer. Mr. Fullaway has found that the life-cycle of the weevil requires from 105 to 135 days in Hawaii. Considering the hardiness of the parasite and its exceedingly short life-cycle, compared with that of its host, a rapid checking and early control of the pest can be reasonably expected. It is particularly promising from the fact that this parasite was found flourishing in dark, wet, rainy forests in New South Wales, quite comparable with those conditions prevailing in the Hawaiian Islands where the weevil has gained a foothold.

Some Observations on Figs in South-Central Luzon, Philippine Islands.

By Francis X. Williams.

These observations have been developed from a study of certain figs and fig insects which it seemed desirable to introduce into the Hawaiian Islands.

Fig. 1. *Ficus megacarpa.* Young vine at right, mature vine at left, on the tree, *Pentacme contorta.* Mount Maquiling.

They concern themselves mainly with these plants as occurring in their natural habitats and scarcely touch upon the entomological aspects of the subject.

The results are based upon eight months of field work undertaken chiefly on and about Mount Maquiling, near Los Baños, about forty miles southeast of the city of Manila. In addition, three expeditions were made to other forests;

the first to Mount Marivales, in Bataan province, across Manila Bay and nearly west of that city; the second to Mount Banahao, a large extinct volcanic cone some miles northeast of Mount Maquiling; while the third trip included a very interesting cross-country journey on foot, under the auspices of an officer of the Bureau of Forestry, across the rather low mountain range, from the eastern shore of Laguna de Bay, northeast to the Pacific Ocean. Many photographs of *Ficus* were taken and a few of these are shown here.

Fig. 2. *Ficus megacarpa* in fruit on the tree, *Pentacme contorta*. Mount Maquiling.

The Mount Maquiling region is especially rich in species of figs, and I have been fortunate in being stationed at the College of Agriculture, at the foot of the mountain, and where every help has been given me in my work, both by the Bureau of Forestry and the College of Agriculture here. My thanks are also due to E. D. Merrill, Director and Botanist of the Bureau of Science, in Manila,

for criticism, and particularly for the identification of most of the figs I collected.

Many hundreds of species of *Ficus* have been described, and these are distributed mainly over the tropical and subtropical parts of the globe. About two hundred are known from the Philippines and an equal number from New Guinea alone! To a certain extent, the writer has studied the comparatively inconsiderable number of about forty-five species, but since these represent several types of plants the collection may be regarded as fairly typical. I have refrained thus far from calling figs trees, for while probably the majority may be so designated, not a few are mere shrubs, while others are vines. Furthermore, one must not get the impression that even a fair proportion of the species of wild *Ficus* bear

Fig. 3. An *Eugenia* sp. tree being strangled by *Ficus clementis.* The vine mainly on the left side is *Ficus megacarpa.* Mount Maquiling.

delicious figs; the contrary is true. Here about Los Baños I have found but three species of palatable figs, and these are distinctly inferior to the figs of commerce.

For the purposes of this very general paper, fig plants may be separated conveniently into four groups, as follows:

(1) Stout lianas, or vines, climbing high up on the trunks of trees, their foliage not being very ample. Few species.

(2) Sprawling or climbing shrubs, that grow over boulders, logs, stumps, or upon trees. Not very strongly clasping. A moderate number of species.

(3) "Baletes" or Strangling Figs, which commonly kill their tree host by very tightly enmeshing the trunk with a network of roots which finally grow together, the underground roots and the foliage also interfering; the host is ultimately smothered and disappears. Numerous species.

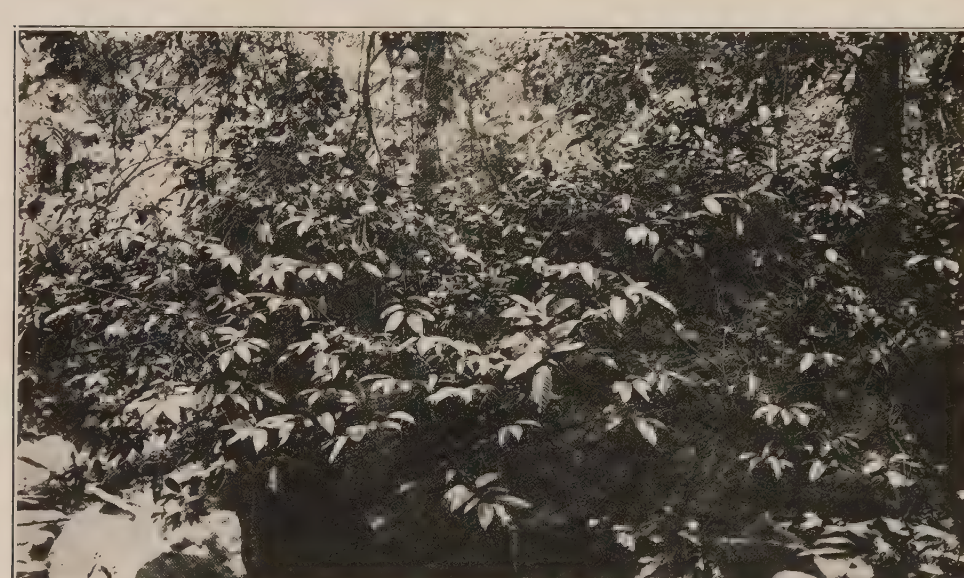


Fig. 4. *Ficus subulata* sprawling over a boulder. Mount Maquiling.

(4) Figs neither vine-like nor stranglers, but growing as independent trees or shrubs. One subdivision bears figs from twigs in the usual manner; the other is cauliflorous, that is, the fruit is borne on special branches or tubercles from the trunk or larger branches. Numerous species.

These four divisions are not wholly natural or scientific, inasmuch as the flowers and fruits have not been considered, and these of course form the basis of plant classification. The third division here includes baletes only and these bear figs, each and all of which, as far as observed, contain male, true female, and gall flowers, the latter being modified for the development of the *Blastophaga* or fig-pollinating wasps. Divisions one, two, and four have male and female plants; that is, the male plant bears figs containing perfect male flowers and gall flowers, while the female tree bears figs with true seed flowers and per-

haps also imperfect male flowers. Variations tend to complicate this classification.

In the first group, I have found but two species, *Ficus Bakeri* Elm. and *Ficus megacarpa* Merr. growing as stout lianas. Neither appears to be an important element in the forests. A specimen of *F. Bakeri* was noted growing upon an immense strangling fig, *Ficus clementis* Merr., at an altitude of about

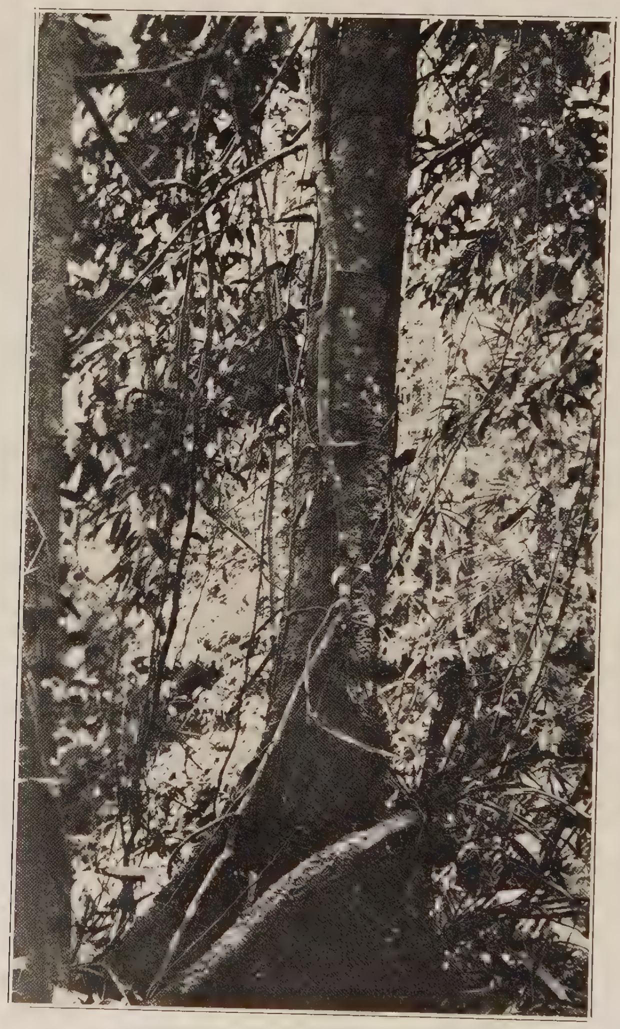


Fig. 5. *Ficus caudatifolia* embracing its host.
Mount Maquiling.

1500 ft. The stout cable-like vines of *F. megacarpa*, often three or four inches thick, are fairly common on tree trunks at lower and middle elevations to two thousand feet or so in the Maquiling forest. In early life the plant is a delicate little vine (Fig. 1, right side), clinging along a tree trunk by means of rootlets. Such vines may arise also from one of the main roots below ground. The stoutest of the three vines in Fig. 1 is the basal portion of a mature *F. megacarpa* growing

on the dipterocarp, *Pentacme contorta* Merr. and Rolfe, while Fig. 2 shows a more distant and extensive view of the same individual fig with several dozens of its nearly spherical fruits along the stem. In Fig. 3 is shown *Ficus clementis* enmeshing a large *Eugenia* tree, while crossing it from near the base, from right to left, and running mainly along the left side of the trunk to the crown of the tree, is a large *F. megacarpa*. Here at the base of the crown it sends out a few inconspicuous leaves.

Fig. 6. A large strangling fig with bird's-nest ferns (*Asplenium* sp.) upon it. Tayabas Province.

Ficus megacarpa is related to the climbing fig, *F. heterophylla,* introduced years ago into Hawaii. It has the largest fruit of any fig that I have seen, for these may attain a diameter of 8 cm., or about 3⅛ inches. When ripe they are of an orange or russet color. The milky juice is exceedingly viscous and makes their dissection a disagreeable matter.

Ficus, probably *lamaensis* Merr., and *Ficus,* probably *apiocarpa* Miq., I observed as rather slender vines on the trunks of trees. *F. apiocarpa,* with its tolerably large and handsome leaves, grows at a rather high altitude. Neither of these two vines was found in fruit.

The second group also contains relatively unimportant plants, three species of which are known to me. They are climbers or semi-climbers and do not attain

Fig. 7. A large strangling fig in Tayabas Province.

a large size. *Ficus subulata* Bl., Fig. 4, sprawls over boulders along streams. It has rather large shining leaves and small fruit. *Ficus philippinensis* Miq. resembles it but is more of a climber. *F. caudatifolia* is a larger plant than the above two species and has a semi-balete or strangling-fig habit, for it somewhat enmeshes the trunk of its host, but not so tightly as to injure it. (Fig. 5.) Its

striking orange-colored fruits, as much as an inch in diameter, often hang down in picturesque clusters from slender twigs.

The third group is by far the most conspicuously represented in the forest proper, but in the drier lowlands group four predominates. The "baletes" or strangling figs are very abundant on Mount Maquiling up to at least 3000 feet, and on Mount Marivales extend well into the mossy forest. They are not found to be plentiful along the trail on Mount Banahao, and only moderately so, but more as large trees (Figs. 6 and 7), in the better Tayabas forest. Along the Pacific shore of Tayabas, a little south of the town of Infanta, they were plentiful just behind the beach, where, according to the nature of their host, they existed as large, more or less erect trees, or else inclining and spreading awkwardly.

On Mount Maquiling is a great variety of strangling figs, some vine-like, others trees of fantastic shapes, others still huge, erect, and wide-spreading.

Fig. 8. Roots of *Ficus adamii* going down to water. Mount Maquiling.

These plants require considerable moisture, and in the lowlands occur mainly along watercourses or lakes. Where necessary they send down long roots to moisture. Fig. 8 shows roots of one individual of *Ficus adamii* Elm. dipping into a stream in the Maquiling forest. A large specimen of *Ficus calophylloides* Elm. sent down a stout root from the base of its trunk, for some eighty or more feet to a small stream bed.

Strangling figs are commonly known in forestry as "weed" trees. While rather a detriment than an asset in a commercial forest, these trees make a fair addition to the watershed cover. Some of the species are among the largest trees in the forests.

They are not properly parasitic, for although attaching themselves to trees, they begin life as epiphytes, i. e., "as a plant growing on another plant but not nourished by it," usually lodged well up upon their host, having started from a

seed dropped there by some bird or other creature.[1] The young fig sends down roots to the ground. These roots increase in size, branch and fuse with one another, forming a sort of tight network around the trunk. The combination of the fig's foliage and enmeshing roots interfering with the growth of the tree above and below ground may eventually cause its death. Fig. 9 illustrates a fig commencing to strangle a breadfruit tree; while in Fig. 10 the host has al-

Fig. 9. A young strangling fig commencing to strangle a breadfruit tree. College of Agriculture, Los Baños.

ready succumbed and rotted away, leaving the hollow framework of the fig in its stead. Such a framework may thicken its meshes so as to appear as, and

[1] In Hawaiian forests, Ohia lehua trees usually start their careers exactly as does a young strangling fig. The Ohia seedling, however, almost invariably perches upon a tree fern, which it gradually enmeshes and smothers in a network of roots.—Editor.

perhaps eventually to form, a solid trunk such as the one illustrated in Figs. 11 and 12.

While I observed about twenty species of strangling figs on Mount Maquiling, no individual kind was seen in sufficient numbers to justify any other than very general conclusions about the habits of a few. Thus *Ficus pruniformis* does not appear to develop a large stem, but exists in a vine-like condition except for the

Fig. 10. The hollow framework of a strangling fig. Its host has rotted away. Mount Maquiling.

profuse branching and leafing out at its summit. *Ficus calophylloides* in later life usually has a more or less cylindric and solid appearing trunk, or sometimes a pair of stems fusing higher up (Fig. 13). I believe it is about the finest strangling fig here, sometimes one hundred and ten or more feet tall, with a crown of a spread of one hundred and eighty feet or more and a trunk diameter, several feet up, of five feet. *F. clementis* is another fine tree which reaches a great size.

The form, size, and sturdiness of the host-tree have much to do with the appearance of the fig, as the latter may be said to replace eventually the tree to which it has affixed itself. Thus the great harp-like *Ficus clementis* (Fig. 14) seems to have developed on two trees; Fig. 10 shows a fig shaped on either a bent or comparatively weak host; in Fig. 15 it appears to have sent down roots for further support, these have grown quite thick; in Fig. 3 the *F. clementis*

Fig. 11. *Ficus indica.* Mount Maquiling.

would be expected to develop into a good straight tree, if it should be self-supporting when its host, *Eugenia* sp., dies. In Fig. 16 the strangling fig forms an awkward picture in sending out two long arms from its central host, a breadfruit tree, but this fig cannot be considered mature and may yet form a rather shapely tree. The crown of a strangling fig is often quite irregular and rather open, its branching not appearing well planned out.

Many of these trees are largely deciduous during the dry season. They do

not appear to interfere more than, or as much as, other large forest trees do with the growth beneath their canopy, and saplings and small trees may occur under them. They are often an improvement in appearance over the host they have killed, and may be said usually to develop a wider crown than the latter, because, in part perhaps, they often branch out below much or most of the branching of the host itself, and the foliage seeks the light both from the sides and upwards.

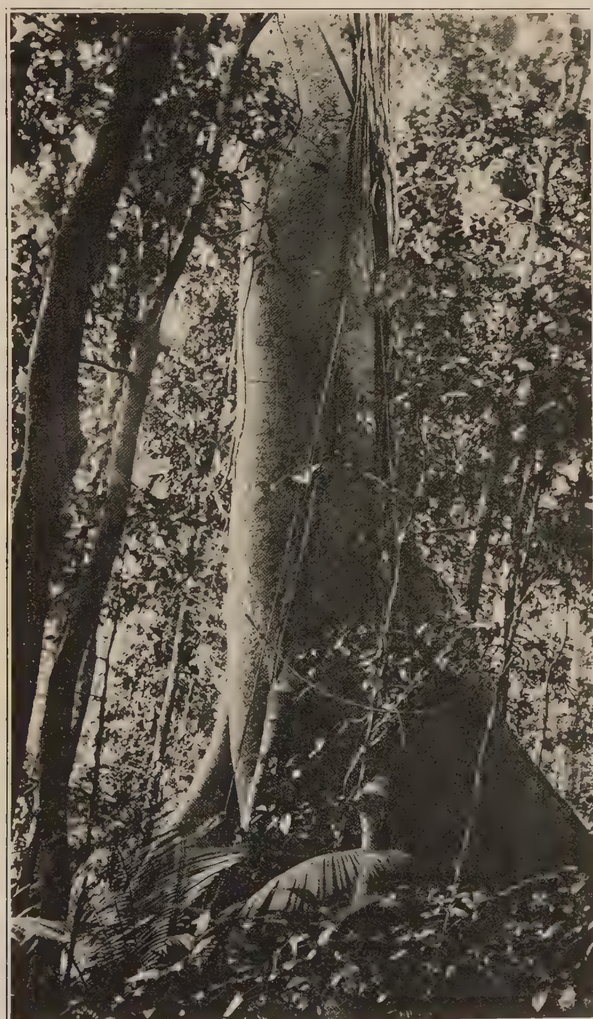


Fig. 12. *Ficus calophylloides.* Mount Maquiling.

There appears to be hardly any choice of host for strangling figs. Among the trees that I have found them attacking in or near the forest were very often other strangling figs and those of group four, *Eugenia* sp., *Dillenia* sp., *Bischofia javanica* Bl., *Artocarpus communis* Forst., *Celtis*, and *Zizyphus* sp. I think it is a matter of the young fig finding a good starting place, as the crotch of a tree,

a broken and decayed branch on a tree, a crack or hole in the trunk, among leaf-bases of certain palms, etc. Decayed stumps are also accepted, and even cracked stone walls, as I observed in Manila. Rocky banks will sometimes support certain species. Very young baletes are not commonly seen in the forest, though one may overlook them time and again, growing quite unhidden. I think, how-

Fig. 13. *Ficus calophylloides*, with double stem. Mount Marivales.

ever, that they usually start their growth high up on trees, where conditions are better and where they would not become conspicuous for some time.

While strangling figs, with proper care, will grow readily from seeds, when planted directly in soil, these seeds are quite small, and hence the tender little plants undoubtedly find the struggle for existence on the forest floor very severe. No sooner has a fig fallen, and even before it has started to decay, than it is at-

tacked by additional insects, and while many of the latter eat the rind only, certain ubiquitous ants carry away quantities of the seeds. I have not yet observed strangling fig seedlings growing on the ground in the forest, and I think that all or nearly all there begin life as epiphytes on trees or tree remains. And yet many thousands of figs, each fig containing often a large number of seeds, fall annually or semi-annually from baletes upon the rich soil below.

Fig. 14. *Ficus clementis.* The inside of the inverted V is at least forty feet high. Mount Maquiling.

The fruit of these figs is quite varied and ranges from 5 or 6 to 35 millimeters or more in diameter. More often they are glabrous and globular, though some are ovate or oblong and with or without stems or peduncles. When ripe, some are greenish, others yellow, red, or very dark purple. The large ripe figs of *Ficus calophylloides* have a very pleasant nectarine odor, easily detected from some little distance; those of *Ficus camarinensis* are scented somewhat like a

prune or plum. Their flavor, however, is far inferior to the perfume and I have found none pleasantly edible. Besides possessing an inferior flavor, the interior contains a mixture of true seeds, chaff, gall seeds, male flowers, and dead insects. Monkeys, bats, and birds patronize a balete and enjoy a feast for the short time that the tree is in ripe fruit, the latter usually maturing almost all at once.

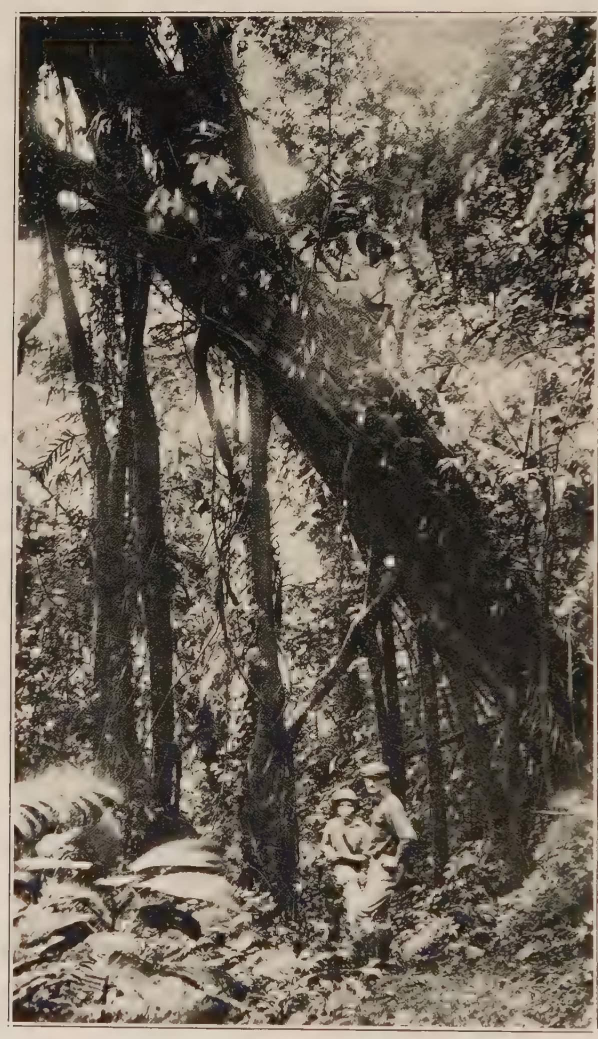


Fig. 15. *Ficus indica* at the edge of the "mossy forest." Mount Maquiling.

I have not seen such a wide variety and perhaps abundance of strangling figs anywhere as on Mount Maquiling. Brown and Mathews, in speaking of Philippine Dipterocarp Forests (Philippine Journal of Science, IX, p. 424, 1914), say that: "These strangling figs frequently occur on the largest trees, but are much less numerous in the best forests than in the poorer types." Thus they abound in the much cut over forest on Mount Maquiling, where there is considerable

light and perhaps more available starting places for the seeds than in those areas where a better and more uniform stand of tall trees prevails. It is to be noted, however, that strangling figs are also plentiful on Maquiling well above the culled forest, and this also seems true of Mount Marivales. As an example of their abundance on Mount Maquiling, I found three trees within a radius of thirty feet supporting altogether seven specimens of baletes, apparently all different species. The three trees concerned were one medium-sized *Eugenia calubcob* C. B. Rob. and two large Tuai, *Bischofia javanica* Bl., and one of the latter supported three species of figs. Such crowded abundance, however, is perhaps unusual, but it is very common to find one host supporting two species of figs, and probably the oldest fig becomes a host later on.

On the flat lowlands about Los Baños I have not found these figs on trees under cultivation, except for a single very youthful example in an old wound

Fig. 16. *Ficus* sp. strangling a breadfruit tree. College of Agriculture, Los Baños.

on the stem of a royal palm (*Oreodoxa regia* Hbk.). I have twice noticed them on breadfruit trees (*Artocarpus communis* Forst.), but never on the mango (*Mangifera indica* Linn.).

In city parks young indigenous figs may gain a lodging on trees or palms (Fig. 17). One day while in Manila I made it a point to investigate this phase of the subject. The commonest strangling fig grown in Manila is probably *Ficus elastica* Roxb., and that species not being a native has no fig pollinating wasps and consequently no fertile seed to produce offspring. *Ficus concinna* Miq. is one of the few baletes that occurs in or about Manila. It was noticed in only two parks, the Botanic Gardens where no small ones were seen, and in Plaza McKinley, Intramuros District. This little plaza is very small, with the park itself about 150 by 175 feet. It is a well-kept place of lawns, shrubs, and trees, and of the latter most are legumes. There is one fine *Ficus elastica* and five in-

dependent trees of *F. concinna*. From *F. concinna* seeds nine little ones had been produced and were growing as epiphytes, three on date-like palms and the remaining six on leguminous trees, some apparently belonging to the genus *Delonix*. All were on individual hosts and ranged from about ten inches to two feet high. They occupied such places as a dead branch broken off close to the trunk, in the hollow between the trunk's branches where some humus had gath-

Fig. 17. A young *Ficus concinna* (upper left) on a palm in Manila.

ered, or among the leaf-bases of palms. None of these young baletes appeared to be in a flourishing condition, but the mature *F. concinna* struck me as an improvement over their neighbors, the léguminous trees.

In such city parks and gardens strangling figs may show to better advantage than those growing in forests. The city fig is planted from a seed or cutting. From the beginning it has plenty of light and elbow room, and not start-

ing as an epiphyte, grows erect. I found it noticeable that the forest balete, having to struggle for light and space, very seldom has branches curving close to the ground or twigs arising low on the trunk, as do many cultivated ones and those growing wild in open country. Their fruits then, except when fallen, are usually inaccessible to a person standing on the ground. Thus, the services of a forest guard, F. Canicosa, an expert scansorial artist, have been of very great value to me in this work. (Fig. 18.)

Fig. 18. Forest Guard, F. Canicosa, who secured all "inaccessible" figs for me. The large tree is *Ficus clementis.* Mount Maquiling.

The fourth group of figs is a very large one and comprises usually medium to small-sized trees or shrubs. Here belong the somewhat edible figs of this locality as well as those of commerce. The male and female fruits are on separate trees; thus the true seeds having a whole receptacle to themselves are very numerous, and seedlings are not infrequently found, though comparatively few

survive. These trees favor a great variety of situations; some are best represented in the lowlands, a number are to be found in the cool upland woods, while others enjoy a wide range in altitude. None of them are stranglers, and several are quite ornamental and excellent shade trees. Some are very hardy and more or less resistant to fire, in that they will send forth suckers from their base.

Fig. 19. *Ficus pseudopalma.* Large specimen at Forest Station, Los Baños.

This is probably truer of the more scrubby varieties, such as *F. ulmifolia* and *F. hauili.*

Ficus pseudopalma Blanco (Fig. 19), with its slender palm-like unbranched stem or stems and its long ragged leaves crowded at the summit, is certainly an aberration in the genus. It seldom exceeds a height of twenty-five feet and is fairly common in portions of the cut-over lowland forest. It is often burdened with vines. The rather large figs, wedged in at the base of the leaves, are fairly

good eating. This tree, perhaps, is more infested with disagreeable ants than any other species with which I am familiar. It also bears the distinction of having the largest *Blastophaga* wasps, as well as seeds, of any fig that I know of. The species is distinctly ornamental.

Ficus minahassae Miq. is common along streams of the lower levels and also extends to fair elevations. In Benguet Province to the north it occurs up to an

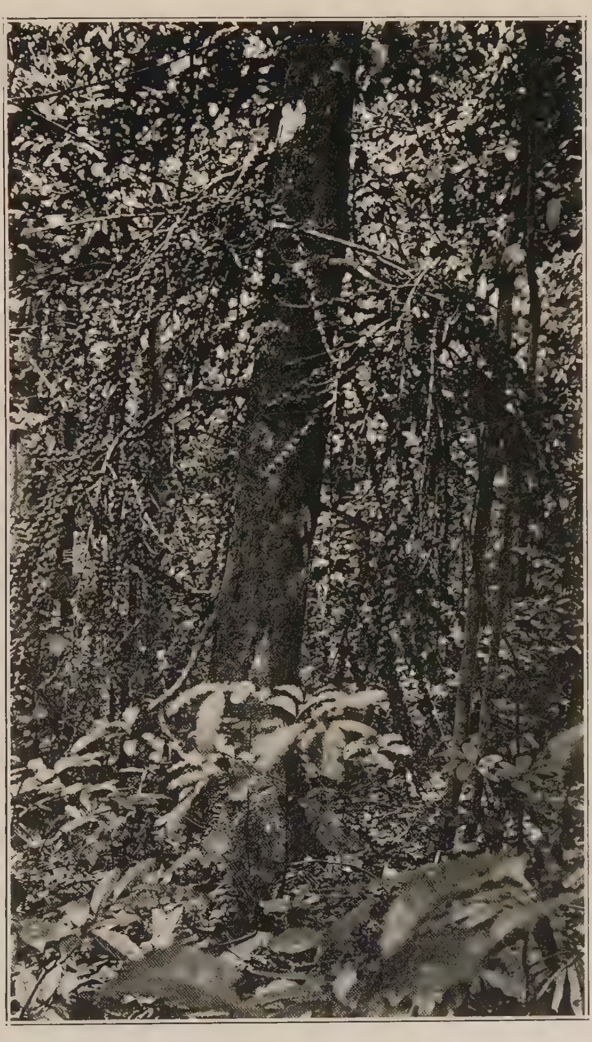


Fig. 20. Specialized fruiting branches or "tubercles" of *Ficus minahassae*. Mount Maquiling.

altitude of 5000 feet. It has a graceful form and a very wide crown, so that it is quite often broader than high. Several may occur together and cast a fine shade. Fig. 20 shows the specialized fruiting branches or tubercles. The female tree bears in clusters on these tubercles many very small but juicy figs, which, while pleasantly sweet, have little flavor. They are quite attractive, however, to small birds. This species bears several distinct crops a year, and while there

may be a great deal of germination among the fallen fruits, I have found a very small percentage of survivals in the young plants. *Ficus minahassae* is remarkable in the genus not only for its very long specialized pendulous fruit-bearing branches, but also because it is the only species in the genus where the small figs are crowded into more or less globose glomerules. By Miquel it was made the type of a distinct genus. It occurs throughout the Philippines; otherwise it is known only from Celebes.

The common Tibig, *Ficus nota* Merr. (Fig. 21), is often conspicuous for its ample bunches of large figs, Fig. 22, which occur along trunk and branches. It is a small tree but an important element in many places along lowland streams and in cut-over lands. It has large leaves and is a good shade tree, though probably short-lived. Its fruits, which are often over two inches in diameter, may be purplish in color, but usually greenish or yellowish-green and brownish. They

Fig. 21. *Ficus nota* in a newly-cleared area. Mount Maquiling.

are quite unpalatable. Seeds of this fig can be secured in quantity. I have also found *Ficus nota* at an elevation of about 3000 feet on Mount Maquiling.

There are many other cauliflorous species more or less similar to *F. nota,* of which the "Tangisan buyawak," *Ficus variegata* Bl., growing in the forest, is about the largest.

Perhaps the commonest fig growing in waste places of the lowlands is *Ficus ulmifolia.* It is scarcely more than a shrub and appears more subject to the attacks of insect borers, leaf- and fruit-feeders than any other species. The fruits are numerous and the female ones edible.

Ficus hauili is another shrub or small tree with much the same habitat as *F. ulmifolia,* but it is a handsomer plant, with shining green leaves. It extends a short distance into the forest. The fruit of *F. hauili,* as well as that of *F. nota,* insipid as they are to us, form a favorite food for certain frugivorous bats.

In the lower levels of the regions visited there is really no cold weather, while the dry season is not of a very parching nature. Hence the various figs may and do bear, more or less, throughout the year. For while a certain individual plant may not be expected to fruit for six months or so, as seems to be common among strangling figs, another individual of the same species may be in full bearing at this period, a third might have young fruit, and so on. This

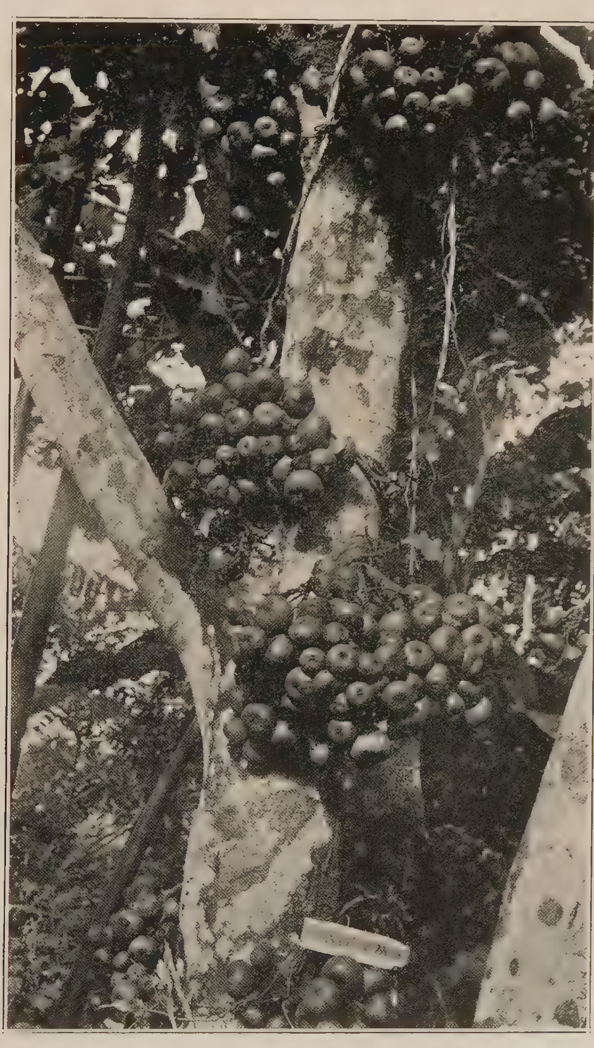


Fig. 22. *Ficus nota* in fruit. Mount Maquiling.

was observed with several species, as *Ficus calophylloides,* with crops on different individuals representing December, March, May, and so far, July or August, and with *Ficus* sp. whose fruiting period occurs in many months. A single individual of the latter species has already borne two crops, one in January and the other in June, with some still small and green fruit accompanying the latter crop. In group four, there appears to be a closer succession of crops. One tree of *F. minahassae* has, up to the present, borne a crop in December, March, and July, the young figs literally pushing their elders off their perches. A female *Ficus ulmifolia,* until recently, has had fruit in all stages for several months. *Ficus*

nota usually starts another crop as scon as the mature figs drop off. A single tree may also have a quantity of fruit in different stages.

Fig trees have many enemies and many patrons. In fact the fauna attached, habitually or otherwise, to species of the genus *Ficus* would make a study in itself. Weevils, moth caterpillars, and fly larvae infest the fruit, beetle borers attack the soft wood, and a large assortment of insects damage the leaves and twigs. Various bugs suck the juices of the fruit, and scarabeid fig beetles are

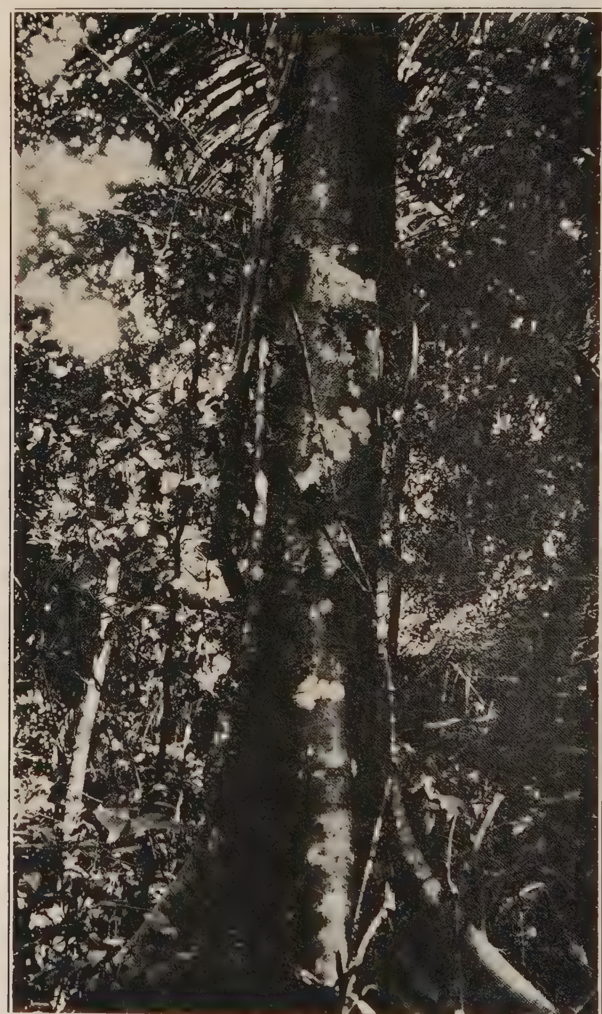


Fig. 23. *Ficus integrifolia.* Mount Maquiling.

common, as on *F. ulmifolia,* for example. The seed production is interfered with by some gall wasps which, in producing galls of their own, crowd out the true floral parts. Fruit-flies, I do not believe, have been reported as attacking the sound fruit in this region. Monkeys, bats, hornbills and other birds frequent certain species of figs when these are in ripe fruit.

In conclusion, it may be suggested that figs of groups one and two are not very important forest elements. Figs of group three are a conspicuous element and usually thrive where they can reach water. They grow well up to 3000 feet or more. Perhaps not all of the species would make desirable introductions if their respective fig-wasps were to be introduced later. This would probably apply more to the vicinity of towns and parks.

Fig. 24. *Ficus mindorensis* in fruit. College of Agriculture, Los Baños.

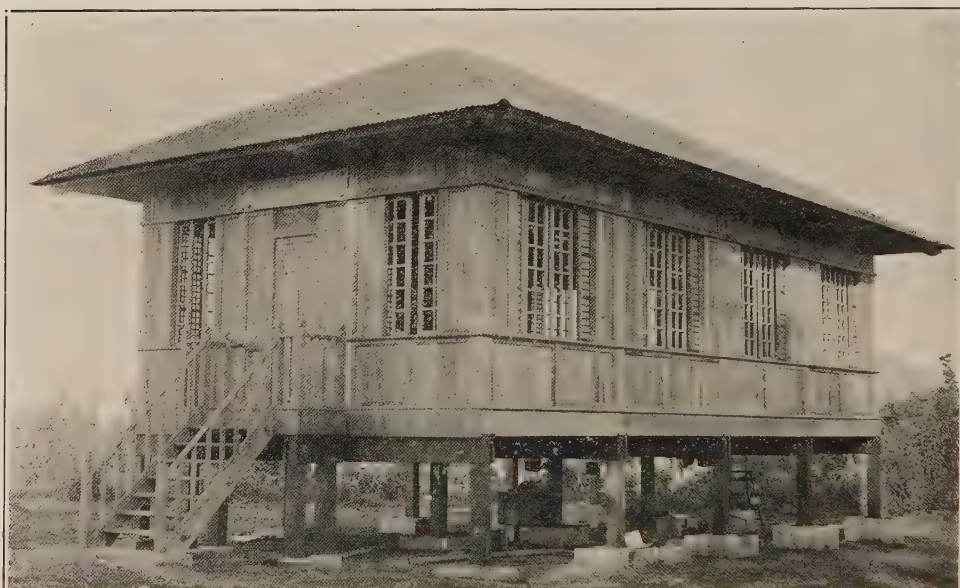
Strangling figs do not appear to be pests here as certain ones are in some other portions of the Orient. Some Philippine species, no doubt, would prove useful, both as shade and ornamental trees. Group four contains several desirable forest trees, from a point of forest cover, and I think that the fig-pollinating wasps of such species as *Ficus nota* and *F. minahassae* could be brought into Hawaii without much difficulty.

The Hawaiian Sugar Planters' Insectary, Los Banos.

As an expression of appreciation for the cooperation extended in entomological work, the Hawaiian Sugar Planters' Association, in January of this year, presented the College of Agriculture of the University of the Philippines the insectary shown here.

"The 'Hawaiian Sugar Planters' Insectary,' so labelled over the door, is up and ready for business," writes C. F. Baker, Dean of the College, to F. Muir. "You will note that the supporting posts are set in cement with a deep furrow about each post for insulation against ants. For the same reason, the landing above the steps is entirely disconnected from the building.

"The building is very commodious, window tables all around, a large re-



ceiving table in center, water installed with special provisions for drainage. Altogether it is one of the best things of the sort in the Orient, and I believe that both the Hawaiian Sugar Planters and the College of Agriculture are to be warmly congratulated. May it be equally of service to both entities!"

It will be recalled that our entomologists made their headquarters at the College of Agriculture at Los Baños during much of the campaign that resulted in the successful control of the Anomala beetle by the Scolia wasp.

The suppression of the pest has meant thousands of dollars to the sugar industry of these Islands. Had it spread unchecked, its damage by this time would have reached serious proportions.

While studying *Ficus* insects and wireworm parasites, F. X. Williams is now making his headquarters at Los Baños and is enjoying the facilities of this insectary.

The Betterment of Industrial Relations.

A Message to the Plantation Skilled Employees.

By Donald S. Bowman.

The betterment of industrial relations is one of the problems constantly before the plantations of Hawaii nei. It is our wish to improve general living and social conditions in a sane, practical manner, going as far as finances and good judgment permit in order that those residing on the plantations may lead a healthful, contented existence.

If we are to improve morale, and it is vitally necessary that we do consider morale, for no battle was ever won except where there was good morale, it is essential that we consider the working and living conditions of our employees. Their health, recreation, religious and social life cannot succeed in the largest sense without guidance and help from the plantation skilled employees.

If plantation industrial service work is carried on in the proper spirit, the result will be a contented people working for the best interest of the plantation.

We do not wish the plantation skilled employees to feel that the industrial service work, which includes all of the so-called welfare work, is paternal in character, and that the plantation is handing them out these things to create loyalty. Just the opposite is true. The plantation realizes its duty to the people residing within its boundaries, and since the first plantation was established it has been the custom to provide free medical treatment, houses, etc.

As in other parts of the world, conditions have changed, and we, who have the reputation of leading the world in up-to-date sugar production, must also keep abreast of the times in that most important branch of our work, the improvement of our man power. We have spent much time and money in perfecting our mills, in the improvement of farm machinery, the propagation of cane, the control of pests, etc. The man power work which has to do with the improvement of morale rests largely with you, the skilled employees of the plantations. Do you realize that we all look up to leadership and that someone is going to lead the laborers? That someone should be the skilled employee. The personal touch between the skilled and unskilled should be fostered and maintained. Where this personal touch is not maintained the labor leader or agitator gets in his work. The real thing that keeps the labor leaders in their position is the inactivity of the skilled employees, who lack personal interest in the men employed under them.

As the plantation manager is a link in the chain between the skilled employees and owners, so is the skilled employee a link between those below him and the manager. Managers must engender loyalty, cooperation, and interest; so the skilled employees must not only have these ideas, but should advocate them in their daily contact with the laborers.

Our labor problems will be solved only when the laborers are interested in their work and feel right toward the plantation employing them. This can be

brought about only by an improvement in personal relations between the skilled and the unskilled.

Let me tell you what I gathered after a lengthy talk with Mr. Dumas, manager of the Calambra Sugar Company in the Philippine Islands. Mr. Dumas employs Filipinos as labor, semi-skilled and skilled. He also employs white men to fill the higher positions on the plantation. He maintains that to be successful with the Filipinos one must show a personal interest in them, and he places more importance on human relations than anything else. In order to develop human relations and an interest in the plantation he has his laborers formed into companies of thirty men, each in command of a Filipino. Four of these companies form a battalion, in command of a white man. The company commanders are the lunas and the battalion commander is the section luna. The lunas are held responsible for the men turning out to work, and they must investigate every cause for absence, reporting the same to the section luna. If a man lays off without a satisfactory excuse he is personally interviewed by the section luna. The section luna keeps a record of the work of each company, and this record is posted daily. Section lunas are encouraged to learn the names of all men under them. Prizes are given weekly to the best gangs. All lunas go to and return from work with the men, generally marching to and from the fields. The white employees mingle freely with the Filipinos, playing and encouraging them in their games, which develops a good morale.

In going over the matter of handling the Filipino with Mr. Dumas, I gather that these are the essentials as he sees them:

Personal interest in the man makes him realize that you are his friend. Human relations,— show by your actions that you are interested in him, his family, his home, and his life.

Promote interest and contact between the whites and Filipinos. Encourage the whites to take an active interest in sports and amusements carried on by the Filipino. He needs help and encouragement. Arrange for contests and entertainments to keep down labor turnover.

Provide plenty of water and wood, and a place to raise pigs and chickens.

Promote him to semi-skilled and skilled positions if he can fill them.

Develop leaders and you will know all that goes on. There will be no labor troubles.

Filipino nurses are of the greatest help and are depended on to assist in the morale work. They are treated on the same level with the skilled. Their standing should be such as to have the laborers look up to them with respect.

Consider always that the Filipino is unduly suspicious. You must deal honestly and firmly with him.

We find that the ideas of Mr. Dumas are along the same lines of those of Mr. Varona.

We must consider that anything we do that will tie together labor and industry is well worth while. It costs money to train new men, and even though they be laborers, the most valuable man is the one who remains on the plantation, turning out daily. Nothing that can be done will entirely prevent men from moving from one place to another. It is impossible to compete with those who are offering higher inducements, but we can create conditions that will make a

more contented people and develop team-work and cooperation. We are doing these things and striving to create in the labor a morale that has faith in the plantation.

Here in Hawaii nei, as on the mainland, the day of the big stick in industry has passed, and we have learned the better way of handling our labor with human consideration and relations.

The most successful work on any plantation that has for its purpose the betterment of plantation social and living conditions, is the work that is carried on with the cooperation of the skilled employees. Lacking this interest you will find a larger turnover and discontented people. No matter what activities you have under way which have for their purpose the entertainment of the people, there must be some supervising head, and that person is the one who needs your help and interest in the activities that are being put over.

Community or plantation interest is a wonderful thing to develop, as it makes life more interesting and livable for all. The things most enjoyed for the amusement of the old as well as the young are the sports and entertainments carried on by the people themselves under proper supervision. These activities should be self-supporting.

In supervising industrial service or welfare work we must get away from the idea of paternalism and consider that it is part of our business to create better conditions, and that this work can be carried on with success only with your help, as the interests of the plantation are your interests.

The temptation in welfare work is toward being too paternal. When I say this I have in mind the instructions sent a film distributor by an industrial service worker who had charge of a platnation theater. "Send me no films of society drama, no films that show any shooting or crime, no sex appeal pictures, no comedy showing ladies in tights." What did he have left to choose from? In this connection we are led to a consideration of censorship, a mighty delicate thing to handle. We can, however, use only films passed by the National Board, which assures as clean films as are produced. It is dangerous to have some local authority decide what is best for our mixed plantation population.

I know of no one on any plantation who could be trusted to assume the moral responsibility for the people who patronize the plantation showhouses. The people must decide for themselves to a very large extent. No local censor will be able to satisfy our movie patrons.

Local censorship has been tried. It doesn't work. The results are continued dissatisfaction and lack of patronage of the locally censored playhouse. The young and innocent must be protected, and this protection rests with the parents. However, a general insistence for cleaner, better films has resulted in a marked and growing improvement. The community must decide what it wants, and these decisions can best be brought out by the skilled employees cooperating with the labor.

The employees of the plantations who are engaged in service work for the people, such as the doctor, nurses, and industrial service workers, are employed to render service to the people, and not to relieve the skilled employees of their work and interest in building up a better community. It is necessary at times for the service workers to resort to publicity to awaken plantation interest, for

by publicity all of the people will become interested in the work of creating a better community spirit. No matter what work we are engaged in, we need help, and how can others help us unless they know what we are doing? This is especially true on the plantations, as no service or welfare work can be operated to obtain satisfactory results unless the activities are backed up by the interest and cooperation of the skilled employees.

After a consideration of the psychology of the various racial groups which furnish us with labor, we have concluded that discontent is not so much a matter of wages as it is a state of mind, or morale, and we believe that every plantation can develop and carry on morale improving work to its great advantage.

The world's economic history teaches us that men are seldom content with what they have. Their wants are limited only by the production of satisfaction. Wants generally multiply from other wants. It rests, then, with us to produce satisfaction, which can be done to a large extent by providing good community life and working conditions. This calls for the hearty cooperation of all plantation employees.

Bud Variation in the Sugar Cane.

That there has been interest in former years in the possibility of improvement of cane through selection of mutations is evidenced by this article, that appeared in 1902 in the International Sugar Journal, reprinted from the West Indian Bulletin, which tells of the work of that day. It remained, however, for the investigations of 1920 and subsequently, based on the improvement of citrus fruit, to reduce the matter of cane improvement to a systematic basis.

Careful observations and exact measurements have shown that amongst animals and plants no two individuals are exactly alike. That this is so amongst human beings and domestic animals is indeed a matter of common observation, and it is by these individual differences that we are able, for example, to recognize one person from another. Amongst plants similar differences, although not so noticeable to the non-critical observer, exist nevertheless. "In every bed of flowers or of vegetables we shall find, if we look closely, that there are countless small differences, in the size, in the mode of growth, in the shape or color of the leaves, in the form, color, or markings of the flowers, or in the size, form, color, or flavor of the fruit. These differences are usually small, but are yet easily seen, and in their extremes are very considerable; and they have this important quality, that they have a tendency to be reproduced, and thus by careful breeding, any particular variation or group of variations can be increased to an enormous extent—apparently to any extent not incompatible with the life, growth, and reproduction of the plant or animal."[1]

[1] Alfred Russel Wallace, Darwinism, 2nd Ed., p. 84.

This tendency to variation occurs amongst plants in a state of nature, and is very pronounced indeed in many cultivated plants. In particular is it to be noted in those plants which are grown on a large scale and in widely separated countries, so that they are exposed to very varied conditions of soil, climate, etc.

The sugar cane exactly fulfills these two conditions, being cultivated on a very large scale and in very distant countries. It has been cultivated for so long that its actual origin is doubtful, but the available evidence points to all the sugar canes grown commercially belonging to one species, *Saccharum officinarum* Linn.

In addition to the favoring factors of extensive cultivation under varied conditions, it has also had the advantage of time, so that it is not surprising to find the sugar cane at the present day represented by countless varieties, differing widely from one another in many characters. Habit, color, vigor, resistance to drought and disease, time of flowering, time of ripening, sugar contents, all vary to a considerable amount. The constant aim of sugar cane cultivators in every country is, or should be, to select those varieties which possess desirable characteristics to the greatest degree.

In actual practice two methods are known and made use of to obtain new varieties of plants, namely, by taking advantage of (1) Seed or seminal variation, and (2) Bud variation.

By the phrase "seed or seminal variation" expression is given to the fact that the seedlings of a batch raised from the same parent plant will differ, both from one another and from their parent plants in various respects. "Some naturalists have maintained that all variations are connected with the act of sexual reproduction; but this is certainly an error; for I have given in another work a long list of 'sporting plants,' as they are called by gardeners—that is, of plants which have suddenly produced a single bud with a new and sometimes widely different character from that of the other buds on the same plant. These bud variations, as they may be named, can be propagated by grafts, offsets, etc., and sometimes by seed. They occur rarely under nature; but are far from rare under culture."[2]

Previous to the independent discovery by Messrs. Harrison and Bovell in Barbados, and Dr. Soltwedel in Java, of the formation of fertile seed by the sugar cane, the first method of raising new varieties was impossible, or at any rate could not be knowingly practiced. It is quite possible that some seedlings may have come up in fields and by chance have got into cultivation. But no organized selection of desirable plants from amongst a batch of seedlings, as is today carried on, could be made. The discovery of the seed rendered this mode practicable; its value was recognized at once, and the success with which the work has been carried on may be estimated by the fact that in the West Indies, at any rate, "seedling canes" have, in many localities, supplanted to a large extent the older varieties. In the sugar cane experiment stations in Barbados alone there are now about six thousand seedlings under experimental cultivation.

The occurrence of the phenomenon of bud variation in the sugar cane has so far been little noticed, and even at times doubted. Messrs. Jenman and Har-

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2 Charles Darwin, Origin of Species, 6th Ed., p. 8.

rison, in their *Report on the Agricultural work in the Botanic Gardens, British Guiana,* for the years 1893–5, write:

"We have no faith whatever in the suggestions often thrown out to select the most saccharine canes of any distinct variety for planting out, as in every stool of canes considerable differences invariably occur in the saccharine strength of the canes, due solely to differences in age and position in the stool and other influencing conditions. We do not consider that a cutting from an older or otherwise favored richer shoot is likely to produce a new plant of superior saccharine strength, and as a matter of fact all our experience disproves this oft recommended idea, and we know of no analogy supporting it apart from seminal generation, no instance of 'bud variation' having ever occurred in our long daily acquaintance in field and laboratory with the cane."

In 1897 Professor J. B. Harrison, in his work on *The Results of Recent Scientific Researches into the Agricultural Improvement of the Sugar Cane* (p. 11), says: "Until recently this mode (bud variation) of attaining an improved variety of cane appeared to be a favorite one with the authorities at Kew. By 'bud variety' is meant the production of a variety distinct from that of the parent cane by means of a shoot springing from an eye. As the search for these 'bud variations' has been recommended by such high authority it is of some interest to ascertain on what grounds the assertion that 'bud variation' occurs in the sugar cane is based. Neither Mr. Jenman nor myself, during our long individual experiences with the scientific observation of the sugar cane — experience probably as extensive as that of any other scientific observers — has ever seen anything resembling a 'bud variation' in the case of the sugar cane, and I think that we are justified in assuming that if such variation ever occurs it is only in exceedingly rare cases."

And further (p. 16): "I do not consider that the improvement of the sugar cane by means of bud sports can be considered as a practical method, or one likely to repay the enormous amount of work necessary to search through many square miles of sugar canes in search of what, at the best, must be of extremely rare occurrence."

Apparently, therefore, no cases of bud variation in the sugar cane had been recorded from the West Indies previous to 1897. The phenomenon had, however, been observed and taken practical advantage of in other countries. In December, 1890, Mr. John Horne, then Director of Forests and Botanical Gardens, Mauritius, in a letter to the Director of the Royal Gardens, Kew, published in the *Kew Bulletin* for 1891, says:

"Raising canes from seed to get improved varieties will be a long and tedious affair, and there will be many disappointments before a really good hardy sugar-yielding variety will be obtained. I think it probable that more and better results will be obtained by good cultivation and by new varieties from bud sports. Of these last we have eight or nine in Mauritius alone; some of them are very fine canes and they are extensively planted. Most of them are hardier than their parents and yield more sugar. They are mostly obtained from new canes recently introduced. The sudden change of climate, soil, and other circumstances causes them to be thrown off. More of them might be obtained if the planters were more observing than they are and closely followed the cane cutters when

cutting the canes. Thus they would range all their fields over, perhaps areas amounting to 1,500 acres, matching each cane as it is seen cut. As things are, a new variety is only observed should it chance to spring up in an outside row."

Dr. Dubbs also, in his book on the *Sugar Cane*, the preface of which is dated June 30th, 1897, records (p. 66) the following experiments carried out in Louisiana:

As an illustration of bud variation, eight years ago some stalks of cane, partly white and partly purple, were selected from the field of Soniat Bros., Tchoupitoulas plantation. They were called by them bastard canes. These stalks were taken and planted as follows: First row, the entire stalk; second row, the white joints of each stalk; third row, the colored joints of each stalk. At the end of the season four distinct canes, as far as color could direct us, were obtained. Types of the four new varieties were selected and separately planted, and the next year were found to be nearly pure. Selection and separate plantings have been made each year since. These canes have been named as follows: First, a white cane, No. 29, Soniat, after the owners of the plantation; second, a light striped, No. 59, Nicholas, after the then Governor of our state; third, a light purple, No. 64, Bird, after the then Commissioner of Agriculture; fourth, a dark striped, No. 65, Garig, after the other member of the Board of Agriculture. The yield and analyses of these canes have been annually made. They, except the white, are entirely different from any other cane in our collection.

"They are now permanent canes in our collection, and with the exception of the striped varieties, which have the tendency of all ribbon canes to vary under cultivation, are fairly permanent in their typical characteristic, viz., color. Their sugar contents are fully equal to those of our home ribbon and purple canes, over which they have as yet no pronounced excellencies. They are cultivated as evidences of bud variation."

In view of the fact that no cases of bud variation in the cane have, apparently, as yet been brought to notice in the West Indies, it is desirable to put on record two instances which have recently come under observation.

The first case was forwarded to the Department of Agriculture by the Hon. F. J. Clarke, from Kirton plantation in Barbados, and exhibited by Dr. Morris at a meeting of the Barbados Agricultural Society in April, 1899. The specimen in question was a ribbon or striped cane, the ribbon being well pronounced on the main stem. Four successive joints had thrown off shoots, the first and third of which were striped with red like the parent cane, whilst the second and fourth were unstriped, yellow canes. Four following joints, therefore, on one cane, bore alternately striped and unstriped shoots. The resulting appearance was a striped parent cane bearing, on the one side two striped shoots, and on the other side two unstriped shoots.

In March of the following year Mr. S. B. Kirton, proprietor of Arthur Seat plantation, Barbados, observed several clumps (stools) of cane showing bud variation growing in the hedge-row of a field on his plantation. This field was examined with very interesting results.

In the case described above it will be remembered that one individual cane had given rise to side shoots, some of which were striped and some unstriped. In the Arthur Seat canes the variation had arisen earlier in the plant's growth,

and the whole canes, as they sprung from the ground, were either striped or not. A single clump dug up had a most striking appearance. From a common base sprang, on one side red striped canes, and on the other side pale yellow unstriped canes.

The examination of five clumps in which the phenomenon was noticed gave the following figures:

Clump	White Canes	Red Striped Canes
A	6	6
B	9	6
C	6	4
D	5	6
E	1	16

One of the clumps was submitted to J. R. Bovell, who reported: "After careful examination I am satisfied that in this clump of canes there is a decided case of 'sport,' or bud variation, as the piece of cane originally planted was a bit of ribbon. From a bud of this ribbon cane there was produced a white cane, which in turn produced from a bud below the surface of the ground a ribbon cane.

"A curious circumstance in connection with this case of bud variation, is the resemblance of the white canes to the Burke seedling cane.

"As you know, Mr. Webster, the manager of Arthur Seat, when showing you the clump pronounced the canes to be 'Ribbon and Burke,' and certainly the resemblance is so great that had I been shown the white canes and been asked to what variety they belonged, I should have said the Burke."

Subsequent to these observations in Barbados, James Clarke of North Queensland, in a letter to Professor J. B. Harrison (for a copy of which we are indebted to him) records the following interesting facts:

"Regarding bud variation, I may say that the first time I noticed this was in New South Wales, where I had charge of a large sugar plantation. At that time the 'gumming' disease in sugar cane was at its height, and the cane called Striped Tanna came suddenly to the front as a hardy, healthy, disease-resisting variety.

"A few hundred-weights of this Striped Tanna cane were received and planted out on the plantation I had charge of, and when cutting those canes for plants at eleven months' growth, I noticed here and there a few thin, weakly-looking stalks, quite yellow, and also some purple colored ones without any stripes. Now, as I had planted these few hundred-weights of striped canes with my own hand, I knew for certain there could be no mixture of varieties, and I was more convinced of this later on by finding a stalk from amongst the striped canes with the three lower joints next the ground striped like Striped Tanna and the upper portion of the stalk unstriped and completely yellow. On seeing this I kept all the thin yellow stalks, and also the purple ones, and planted them out separately, and the resulting canes from those plants came up true to color. I

also planted the striped lower joints of the cane, that were half yellow and half striped, and the cuttings from the upper yellow portion separately, and got yellow and striped canes from the respective plants, according to color of cuttings planted.

"When cutting Striped Singapore canes here the other day, I came across what appeared to be ripe yellow Rappoe canes growing out of the middle of the Striped Singapore stools. At first I thought these stalks must have sprung from Rappoe cuttings planted amongst the Striped Singapore canes, but on closer inspection I could see at once that this was not the case, and that those yellow canes must be sports of the striped variety, for after a little further search I found stalks with purple stripes on a few of the lower joints, whilst the upper half or remaining portion of the stalk was of a uniform yellow color.

"Again, to make sure that the yellow canes growing from the center of the Striped Singapore stools were true sports, I dug up a whole stool of mixed canes and sliced the roots through the middle, so as to expose the connections of the different stalks. It could then at once be seen that the striped canes were the parents of the yellow shoots which had sprung from them."

The above scattered observations may be shortly summarized thus:

1. Bud variations occur in the sugar cane.
2. They have been recorded from widely separated countries — Mauritius, Louisiana, West Indies, and Queensland.
3. The differences between sport and mother plant are often as considerable as those between recognized distinct varieties of the sugar cane.
4. Bud variation may give rise to:
   (a) Differently colored side shoots on one cane.
   (b) Differently colored canes in one stool springing from the same mother plant.
   (c) A cane with some joints striped and some unstriped.
5. Plants grown from cuttings of the sports tend to come true to color.
6. The cane giving rise to sports, whenever recorded, has been a striped or ribbon cane.

That bud variation is probably not a very rare phenomenon in the sugar cane is demonstrated by the case of Arthur Seat plantation. The instances mentioned from that locality were the result of merely one afternoon's observation, and of the canes along the hedge-rows of one field only. Close observation, particularly at cutting time, as suggested by Mr. Horne, would probably result in many more cases being brought to light. Whether many more instances will be brought to notice or not will depend in the main on the planter. No one observer, however diligent, can closely examine a large area of canes. The labor of getting about, in amongst the mature canes, is too great in the tropics, and he will be limited to those canes which happen to occur along the edges of a field. That this is indeed the case is shown by the instance of Messrs. Harrison and Jenman, who, during all their long experience with, and careful observation of, the sugar cane, had not, at any rate up to 1897, ever seen a case of bud variation in the field.

Beyond the interest which attaches to these observations so definitely proving the occurrence of bud variation in the sugar cane there is the question of their possible economic importance. Previous to the discovery of the seed of

the cane, the use of bud variation, or sports, was recommended by the Royal Gardens, Kew, as a possible means of obtaining new and improved varieties of the sugar cane.

Dr. Morris, in exhibiting the Kirton specimen at the Barbados Agricultural Society, laid stress on its possible economic value. One of his principal reasons, he said, for coming to the meeting was to try to rouse the interest of the planters and get them to look for specimens. If they had a very hardy cane, disease-resisting, and so on, giving out sports, it was quite possible by cultivating a large number of them to get a cane possessing qualities superior to the mother cane. Again, at the meeting in July, 1899, he said that there was a distinct value in these sports, as they afforded a means of obtaining a cane of greater merit than at present. He wished to impress on the Society that the production of sports was not a mere question of curiosity; it was one of very great importance to the Society, affecting as it did the raising of new canes.

The evidence so far available tends to show that many of these sports possess distinct advantages over their parents. It will be remembered that Mr. Horne says (loc. cit.), on the result of his experience in Mauritius: "Most of them are hardier than their parents, and yield more sugar." Mr. Clarke, at the end of his letter, an extract from which was given above, says: "In conclusion I may say that I have also noticed that the yellow sports have a tendency to grow sweeter than the colored canes of the same family. On analyzing purple and yellow sports of the Striped Tanna canes last week, the latter, grown in the same field and under similar conditions and receiving exactly the same treatment as the former, showed double the percentage of P. O. C. S."

In Louisiana, on the other hand, "Their sugar contents are fully equal to those of our home ribbon and purple canes, over which they have as yet no pronounced excellencies." (Dr. Stubbs, p. cit.)

Having regard to the possible value of the sports recently obtained in Barbados, it was very desirable that they should be submitted to a strictly comparative test. To this end they have been planted out at Dodds and at Waterford plantation, in the same fields with other canes undergoing test. In each case the plants from the striped and unstriped canes are growing side by side. On examining them on August 15th, 1901, they were still too young to display fully their mature characteristics, but gave every indication of producing striped and white canes, respectively.

In the coming crop season, about May, 1902, they will be cut, crushed, and analyzed, and the full results published.

Studies in Indian Sugar Canes.

*Tillering or Underground Branching.**

By C. A. Barber,

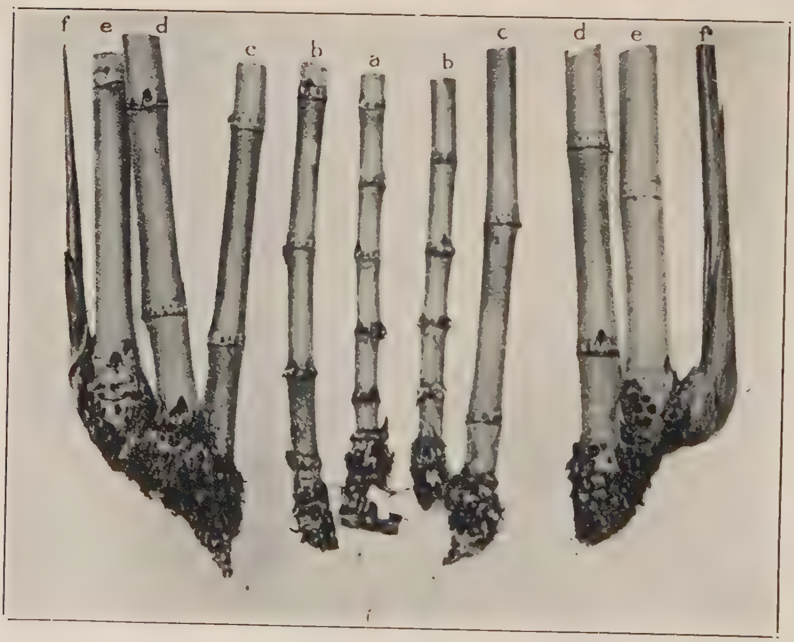
This paper deals with a detailed study of the slender sugar cane types common in India. The general method of studying these cane plants suggests ways of becoming better acquainted with the crop we are producing. It is published here in the interest of what it may contribute to the work of improvement of cane by bud selection. While the Indian cane may differ from the varieties in Hawaii, this difference is largely one of degree.

The present research dates back to observations made in 1913, which showed that, in certain Punjab sugar cane varieties, there were differences in the canes growing in the same clump. These were found to be early and late in origin, the former being thin and long, with short joints at the base, and the latter thicker and shorter and commencing with much longer joints. A certain number of dissections had been made of the underground, branching portion of cane seedlings and wild Saccharums, and it was decided to commence a systematic study of this part of the cane plant in the field, in order clearly to demonstrate the true relations of the differing canes in each clump. As additional points of interest, referred to below, presented themselves, the series was greatly extended, and during the past two years a very large number of cane stools have been carefully studied.

For a proper understanding of the branching system of any plant, it is necessary to follow it from its earliest stages, and a study has accordingly been made of the germination of the sugar cane seed and the sprouting of planted sets.

The important question of tillering soon connected itself with the dissection work, it being well known that, not only do the thick canes differ considerably in this respect among themselves, but, as a whole, they tiller much less freely than the indigenous Indian canes. Unfortunately there appear to be few accurate observations published on the tillering of Indian canes, and our own notes are far from complete. It is, however, hoped that the facts here presented will give a stimulus to this important side of crop investigation. Even in the tropical sugar cane countries, although a vast number of observations have from time to time been made, there are few papers dealing with the subject from a scientific point of view, and the great bulk of the notes made are not available for our purpose. Spacing, which has given rise to so many experiments in such crops as wheat and paddy, appears to have been occasionally tried in sugar cane; but the results are not easily obtainable, and no help can be got from those crops which are grown for the production of grain. A summary has been prepared of the literature of this part of the subject.

* From Memoirs of the Department of Agriculture in India, Vol. X, No. 2 (abridged).



Branches of different orders in the dissection of *Saccharum arundinaceum*. The main stem, *a*, is in the center, and *bs*, *cs*, *ds*, *es*, and *fs* are arranged on each side, passing outwards from the middle.

Attention was soon arrested by the fact, stated by various observers, that, during the lifetime of a cane plant, a great many deaths occur, so that the number of shoots in early stages greatly exceeds that found at crop time. These observations have been made entirely with thick canes, and doubts arose in our mind as to whether they were equally applicable to Indian canes, as the deaths were by no means obvious in the plots. A series of shoot countings once a month was accordingly instituted to throw light on the question, but the results of these are not yet available for publication.

Incidentally, in the course of dissection, it was observed that different cane varieties showed considerable differences in their mode and degree of branching; and not only was this the case with individual varieties, but whole groups could without difficulty be distinguished from one another in this respect. The degree of branching in the Indian canes was seen, as a whole, to differ very considerably from that in thick canes, and this led to a study of that of wild Saccharums, when it was found, as expected, that the Indian canes stood half way between the wild species and the thick canes of the tropics. A further stimulus was thus added to the work, and it was attempted to discover, in the branching of the cane varieties, a means of tracing the origin of the cultivated canes from their wild ancestors, and, among the Indian canes, to select such as might be considered the more primitive, and thus establish a connected series from the wild grasses to the thick canes of the tropics.

Lastly, differences were observed in the richness of the juice in the early and late canes of a plant, and these did not altogether tally with the views held regarding the richness of the thick and thin canes in tropical cane fields. The literature of the subject is punctuated by references to the relative richness in the juice of the "mother" cane and its branches, but, as no dissections seem to have been made, it is difficult to understand how the various observers distinguished these two classes of canes. There is obviously great confusion on the subject, for one observer, after stating his opinion, admitted that the mother shoot need not of necessaity be the original main shoot of the clump, but was the "thickest and best grown"! As will be seen, the result of our study is exactly the reverse, in that the main shoot is thinner and less well grown than its branches. This is indeed perfectly natural, when we consider the available equipment of leaves and roots in the young cane, as compared with that at the disposal of branches formed when the plant has grown up.

The dissection of the cane stool is a rather intricate and laborious piece of work. Upon taking it out of the ground, each clump is seen to be covered by a dense mass of tough roots, among which the soft buds are hidden, and these roots all have to be carefully cut away before the nature of the branching can be seen. The planting material with us consists of sets or pieces of cane on which there are at least three healthy buds, and these buds, usually all of them, develop into larger or smaller plants, which, however, are quite separate and only influence one another as regards the space available for their independent growth. It is usually impossible to make the dissection unless these plants are cut out and dealt with separately.

The main dissecting work was done in the 1916–17 and 1917–18 seasons, and in each year clumps were examined at two stages of growth for entirely

different reasons. The first was at about four months, for the determination of the rate of cane formation; and the second at about eight months, for the study of the canes formed at crop time. It was soon found that, after this latter date, no new canes could be started in time to mature. In 1916–17 the dissections were largely concentrated on the Saretha and Sunnabile groups, which at that time had recently been separated and were being described. Six varieties of each of these groups were examined, and to them were added a few from the other groups and some thick canes and wild Saccharums. Altogether 51 clumps, containing 133 plants, were dissected during this season. The results of this work were so suggestive and interesting that a fuller series was projected for the 1917-18 season. Six varieties of each of the five classes of Indian canes were chosen; to these were added six from the unclassified list, six thick cane varieties, the four wild Saccharums growing on the farm and six Madras seedlings, all of which were grown from sets. Owing to the poor growth of the thick canes, a further set of 24 stools was examined at the sugar cane plantation at Nellikuppam, these being all of the Red Mauritius variety, which was known to grow very well there under crop conditions. During this season 239 clumps, consisting of 629 plants, were dissected. The facts observed during the previous year were utilized for the preparation of a definite scheme of observations and measurements, the main purpose of which was the comparison of the branching systems of the different groups and the characters of the branches of different orders. In each plant dissected a diagram was prepared, in which the relative position of the branches was shown, and a formula was prepared, in algebraical form, of the constitution of the plant as far as matured canes were concerned. Besides this, all the canes were measured as to thickness and length of joints, and notes on runners, curvatures, injuries, etc., were recorded. The present paper seeks to extract the general principles of the branching of the sugar cane plant from this mass of material.

The following are briefly the results of this study. From the four months' dissections it is seen that the different varieties vary greatly in the rate of maturing and cane-formations, but this study is complicated by the fact that it was impossible to examine all the stools at the same time, owing to the large number dissected, the time occupied in the work extending over six weeks. A series of tables has been prepared, from which it is not difficult to judge of the relative rate of maturing of the different varieties.

From the general formulae of canes at harvest, obtained by averaging the dissections of all the plants of a variety, it is seen that the branching in the various groups, from the wild Saccharums to the thick tropical canes, is of the same nature, but of very different degree. Taking a to represent the main shoot, b its branches, c branches of b, that is of the second order, and so on, we get a series of formulae of the canes at crop time, varying from $a—mb—c$ in the thick canes, to $a—mb—nc—nd—me—f$ in the wild Saccharums, and the different groups of Indian canes can be arranged in a series between these two extremes. It is hoped that a study of these formulae will throw some light on the stage of development of each group from its supposed wild ancestor.

The differences in form and size between the branches of different orders in the same plant have been carefully studied. Each cane has been measured

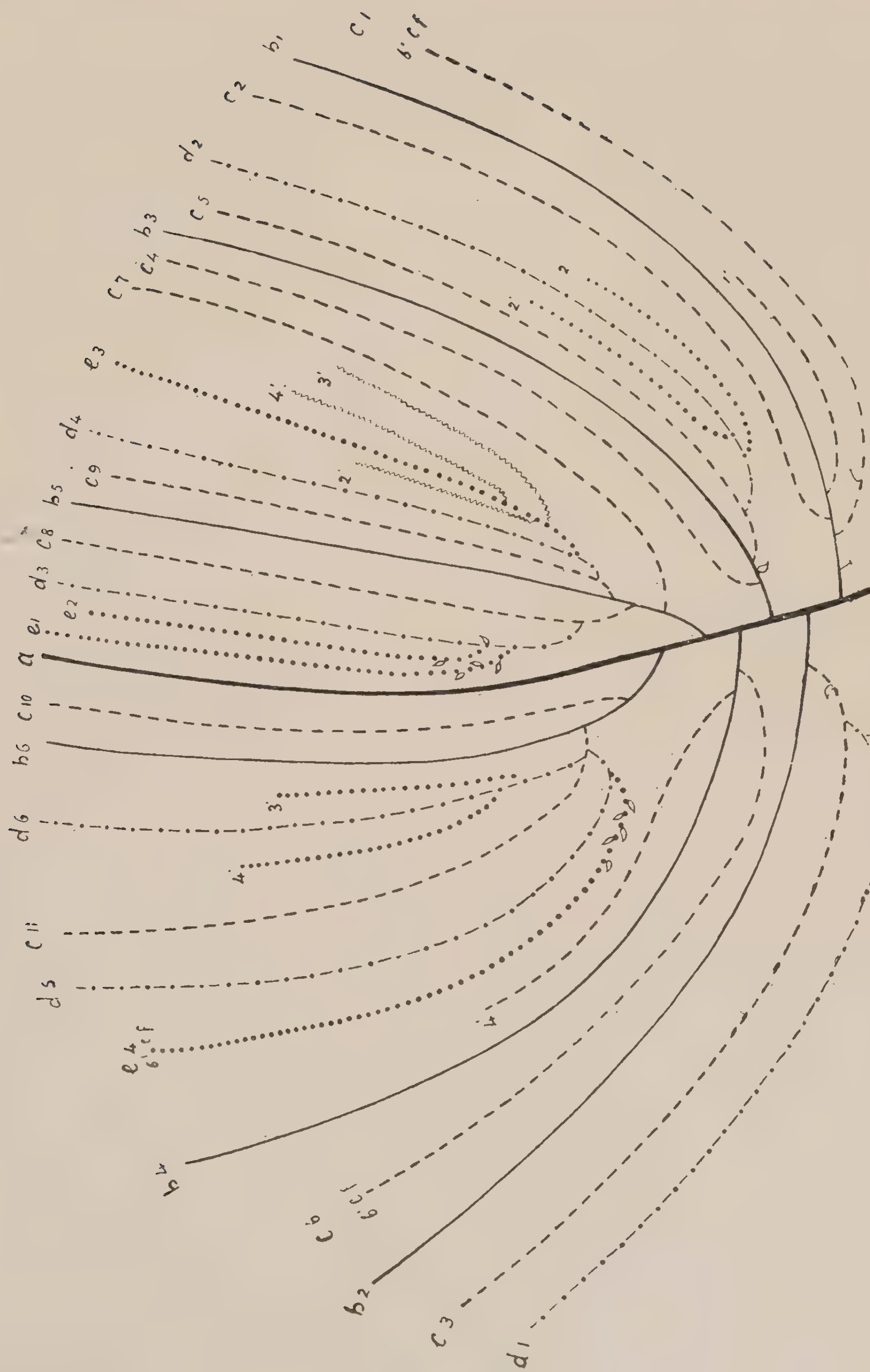


Diagram of the branching system in a plant of *Saccharum arundinaceum*.

as to the length of the basal, branching portion before it has assumed its full thickness, the thickness at two feet from the base, the average length of the joints in these two feet, the presence of curvature and runners, and so on. In all of these characters we find, as might have been expected, that there is a tardier development in the first shoot, and that this development increases in rapidity as the branches of the higher orders are reached. The general trend is for the branches of higher orders to be thicker, to have longer joints, and to show greater curvature. The main shoot has a longer basal, preparatory portion than its branches, but, when we pass to the other orders, the presence of basal curvatures, needed to place them in a position for upright growth, again increases the region of short joints at the base, for it is the general rule that a branch does not assume its full form until it is in a position to grow onward unimpeded.

The characters of the branches of different orders are seen to be so definite that, when a field is cut, we can without difficulty separate the canes at the mill into early and late. There is a good deal of similarity sometimes between the *a*s and *b*s, especially when the latter become facultative *a*s, but the change from *b*s to *c*s and *d*s is sufficiently striking to render their distinction generally very easy. This opens up a new line of work, in that it becomes possible to analyze these branches separately and to settle the question of their relative richness of juice and other qualities at the mill. Most of the work has, it is true, been conducted with Indian canes, and in one particular locality, but it seems unlikely that the thick canes will not fall into line, considering the general similarity of their branching system to that of Indian ones.

Forage Crops.

J. H. Midkiff makes the following observations in regard to experimental plantings of fodder crops for dairy feeding:

"At Lihue Plantation the elephant grass is growing much faster and looking healthier than the Uba cane or any of the sorghums. In a given time the elephant grass is probably producing three or four times as much feed as the Uba cane, and, contrary to expectations, it seems to be standing drought and sea breezes better than the Uba cane. The wild cow pea is not doing well here.

"At Grove Farm pigeon peas are doing fairly well with absolutely no attention. They were drilled into the soil. Since then they have received no fertilizer, irrigation, or cultivation of any kind.

"Mr. Krauss' best variety, the New Era Heavy Bearing, Early Maturing Pigeon Pea, is showing better results than the ordinary variety. The peas have been pastured since they were about two feet high. But until they began to produce seeds the cattle did not learn to eat them to any great extent."

[J. A. V.]

Rat Control Measures.

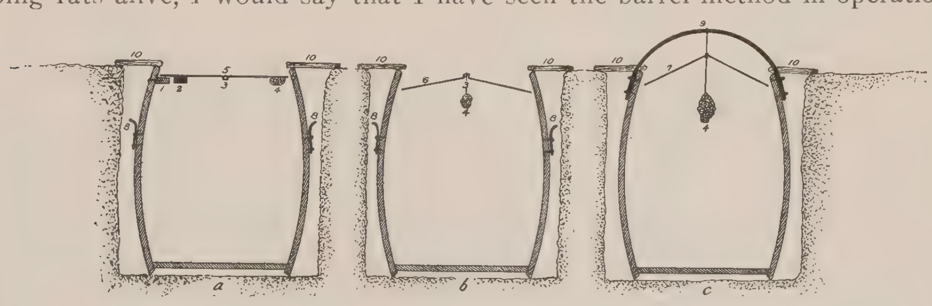
In a recent number of the Literary Digest, reference is made to the system of rat control which was described in the March number of the Record. The article which we published was taken from an English paper.

The recent comment by the Literary Digest on the same idea of control reads:

> The typical nine lives of the cat are apparently surpassed by her enemy the rat. Efforts to exterminate the rat as a plague-carrier have resulted only in increasing its reproduction rate and swelling its numbers, according to Dr. A. K. Chalmers, medical officer to the port of Glasgow. Says the British Medical Journal (London), reporting a meeting of the [British] Association of Port Sanitary Authorities, at which the doctor spoke:
>
> "Dr. Chalmers pointed out that though plague was primarily a disease of rats, there was no evidence that the rat plague in Eastern countries had diminished the number of rats; millions of rats had died of it in India, but there were as many there today as twenty years ago; not only were they numerically as strong, but from a bacteriological point of view their position was even stronger, since they might suffer from a chronic, non-fatal, but transmissible form of the disease. Again, at Copenhagen, when the authorities set out to trap and kill rats, the average catch was about 300,000; it was rapidly reduced by half, but remained at 150,000 for some time. It appeared that as fast as rats were killed the birth-rate rose; it was only by the adoption of a special policy which consisted in killing the females and liberating the males, who fought and exterminated each other, that the catch was reduced to 90,000. The general opinion of the meeting seemed to be that though it was possible to diminish the number of rats on ships it was impossible to exterminate them in the ports."

Any attempt to control rats by releasing the males after having disposed of the females, calls first of all for an effective system of trapping rats alive. A recent report by E. L. Caum pertains to this point:

"In response to your request for a memorandum on methods of trapping rats alive, I would say that I have seen the barrel method in operation



in Pennsylvania, and it seems to me that it ought to work pretty well in the cane fields, especially since the plan would be to kill only the females and release the males. The scheme is very simple, consisting merely of a barrel with a hinged top, the whole sunk in the ground so that the top is flush with the surface.

"The method of manufacture is as follows: (Fig. *a)* a large barrel is taken, preferably one with the sides as bulged as possible. A shallow groove

is cut in each side at the top deep enough to hold a small rod. The head of the barrel (5), which should be in one piece, is then balanced on a slender rod (3) and held in place with staples, so that it will turn freely. Then, when the ends of the rod, which project beyond the barrel top, are laid in the grooves which have been cut to receive them, we have a deep, concave-sided cage with a lid so nicely balanced that a very slight weight will cause it to tip. Now fasten a light weight (2) to one side of this lid, on the under side, or suspend it from the lid by a short wire, and nail a small bit of wood (1) to the inside of the barrel near the top, and on the same side as the weight. This weight and stop serve to hold the lid horizontal. Needless to say, the weight should be heavy enough to tip the lid, or to bring it back when tipped, and no heavier. It would be well to smooth the top of the lid, to make the footing more precarious.

"The bait (4) is fastened to the side of the lid opposite the weight. When the rat goes after the bait, his weight overbalances the counterweight, thus tipping the lid and depositing him in the barrel. The counterweight then brings the lid back to the horizontal, closing the trap and at the same time setting it for the next victim.

"I have seen these traps in operation near barns, where rats were plentiful, and as many as fifty or sixty were caught in one barrel in a night. Of course, that was at the beginning. The catch fell off rapidly, as the available supply of rats diminished. In these places the animals were all killed, so the barrel was set solid in the ground, and kept half full of water.

"Where the object is to keep the animals alive until the sexes are separated, the hole should be dug enough larger than the barrel to accommodate a couple of handles (8), the space around the top being bridged by a wooden frame (10). A hole three and a half or four inches in diameter should be cut in one side of the barrel, at the bottom, and closed with a plug. Then, when the trap is taken up, this plug could be removed and the animals forced into a screen cage of some sort, where the females could be segregated and killed.

"Variations of this plan are shown in figures *b* and *c*. In fig. *b* the lid is made of a disc of zinc (6), bent across the rod (3), with the bait (4) suspended from this rod. This type of lid, while a trifle more difficult to make, dispenses with the stop and counterweight, and has the added advantage of tipping from either side. The shape of the lid tends to return it to the proper position after the animal has tipped it.

"In fig. *c*, the lid (7) consists of a shallow cone of zinc, suspended by the apex from a wire frame (9). In this case the bait (4) is hung directly below the apex. This type of lid has the advantage of tipping from any side, instead of from two, as in type *b*, or, from only one, as in type *a*.

"Type *a* has the advantage of being simplest in construction, as it can be made entirely from material to be found around any plantation camp. Types *b* and *c* both call for a zinc disc, which must be bent across the middle in one case and made into a shallow cone in the other.

"These types are all effective—I can vouch for type *a*, and Mr. Potter tells me that he has seen both *b* and *c* in action. I might suggest that the best bait to use is something aromatic—a piece of fat bacon, for instance."

Hints on baiting rat traps are also supplied by the Literary Digest. From the issue of September 3, we read:

A correspondent of the Daily Mail (London) is quoted in our issue of June 18 as asking, "Why are rats so keen on aniseed and rhodium?" The editor of the Mail understands this to mean the metal rhodium, and indulges in some pleasantry on the subject. Several correspondents, learned in pharmacy, write us to say that "oil of rhodium" has nothing to do with the rare metal of that name. Mr. Edward P. Higby, of the California State Hospital, Stockton, Cal., writes:

"For the information of 'an ex-president of the Electro-chemical Society' and whoever else is only acquainted with rhodium as an element, I quote from the United States Dispensatory:

" '*Oil of Rhodium*—This is said to be the oil from the wood of *Convolvulus scoparius* or *Genista canariensis.* It is used to adulterate oil of rose. *An oil of rhodium is sold to rat-catchers as a lure for rats,* which is made by mixing one part oil of rose with twenty parts oil of copaiba.' "

A. R. Eberle, of Milwaukee, Wis., writes:

"As a druggist, I will say that in regard to rhodium the London writer evidently wrote *oil* of rhodium. This is also used in bait to attract fish, and I feel certain is what the London writer had written."

The Rat Menace in India.[1]

Experiments have been conducted by Major J. C. G. Kunhardt and Assistant Surgeon G. D. Chitre on the eradication of plague infection by rat destruction. The observations made strongly support the view that the reduction in the rat population, resulting from plague itself (which attacks rats), is the main factor in bringing infection to a natural end, and that it yet remains to be seen if the destruction of rats by any artificial means is capable of producing or accelerating the same result.

A number of rat poisons was tested, but none was found better than barium carbonate, of which three grains is a fatal dose for the rat. It is best made into a bait with dough of some grain flour (the best grain was found to be bajri, *Pennisetum typhoideum* [2]), and without any addition in the form of fat, sugar, condiments, etc. (Indian Journ. Med. Research, Vol. VIII, No. 3, 1921, pp. 409, 446).

1 From Nature, August 11, 1921.

2 *Pennisetum americanum* Schum. (synonym, *P. typhoideum* Rich.), pearl millet. Occasionally grown in the southern states, where it ripens seed. A luxuriant annual, long cultivated in the Old World for forage and more or less for the grain, which is used as food.—Bailey, Standard Cyclopedia of Horticulture.

Preliminary Studies on Some Fungi and Bacteria Responsible for the Deterioration of South African Sugars.[1]

By PAUL A. VAN DER BIJL.

The author states that little attention has been given in South Africa to the nature and causes of the deterioration of stored sugars, a phase of research which will demand more and more attention with the increase in export. The study herein reprinted is of a preliminary nature, consisting in the main of results of experiments.

The fungi are now recognized as the most important of the micro-organisms resposible for the deterioration of stored sugar. In this paper four fungi and three bacteria are discussed, all isolated from samples of so-alled "sweating" sugar. The subject matter of the paper is divided into three parts: I. Fungi or Molds; II. Bacteria; III. General Considerations.

In the manufacture of commercial sugar in Hawaii we have largely solved our problem of deterioration through mill sanitation and the reduction of the moisture content in our sugars.

PART I—FUNGI OR MOLDS.

(a) Preliminary Test.

As a preliminary test, the fungi isolated from sugar samples were first tested to see if they contained the enzyme invertase which inverts cane-sugar, and only those which gave decidedly positive results were retained for further study.

To test for invertase the fungoid growths from artificial media were first well washed in water, then crushed with water in a mortar, and after the addition of toluene as a disinfectant left overnight for the enzyme to diffuse out. The following morning the mixtures were filtered, and the following series of experiments set up for each fungus:

Active Extract—20 c.c. 1 per cent sugar solution + 5 c.c. unboiled filtrate + 1 c.c. toluene.
Boiled Control—20 c.c. 1 per cent sugar solution + 5 c.c. boiled filtrate + 1 c.c. toluene.

The flasks containing these mixtures were incubated at 30° C. for twenty-four hours, when the mixtures were tested for reducing sugars with Fehlings solution in the usual way. If any invertase was present in the fungoid extracts then the active extract should show an inversion of the cane-sugar. In the boiled control the enzyme had been destroyed by the heating, and there should hence be no inversion, or, at most, only a slight one, probably from the sugar used. The toluene was, of course, added as a disinfectant to prevent the growth of micro-organisms in the mixtures.

The premliminary test gave a rough idea of the economic importance of the fungi isolated from sugar samples, and for this investigation four of them

[1] Department of Agriculture, Union of South Africa, Science Bulletin No. 12. 1920.

were kept for further study, though I must say that these are not the only ones, and before we have finished with the investigation we will probably have quite a number more.

(b) The Fungi.

An opportunity for studying fully the morphology of the fungi has not yet offered itself, and I consider it advisable to deal with this aspect in a separate paper after more of them have been isolated and studied. For this reason I give only brief notes on the fungi with a few sketches to indicate their nature. They are:

Aspergillus sp.—This same fungus was obtained from sugar at different times, and two isolations of it were utilized in almost all of the experiments.

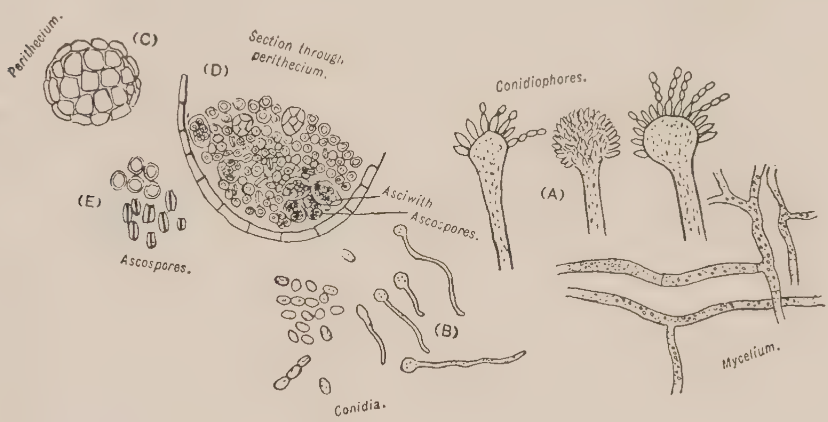


Figure 1. *Aspergillus Fungus*—Life-History of the.

The fungus is illustrated in figure 1. The conidial herbage is greenish and at (a) are shown the swollen conidiophores which bear the finger-like processes from which the conidia are abstricted. At (b) are shown some conidia germinating. The conidia are globular to more or less elongated, with smooth or minutely punctuate walls, and measure 2.4 by 4.8 or 2.4–3.6 μ. This fungus very readily develops another fruiting body, which takes the form of a yellowish case, illustrated at (c), and in which on cutting it across we notice a number of sack-like structures (asci), each of which contains a number of spores (ascospores). Such a section is shown at (d), and at (e) are shown some of the ascospores. The ascospores are ellipsoidal, exhibit a longitudinal furrow, and measure 3.6-4.8 by 2.4-3 μ. Figure 2 shows the fungus growing in the laboratory on artificial media.

Stemphylium—This fungus offered considerable difficulty in placing it, and until such time as it has been further studied it is provisionally placed in the genus *Stemphylium*. The spores are brown in color, large, and divided by transverse walls into many cells. Some of these cells are again divided by a longitudinal septum. This fungus is illustrated in figure 3.

Sterigmatocystis—This genus is not sharply defined from the genus *Aspergillus* mentioned above. In *Aspergillus* the finger-like process arising from the

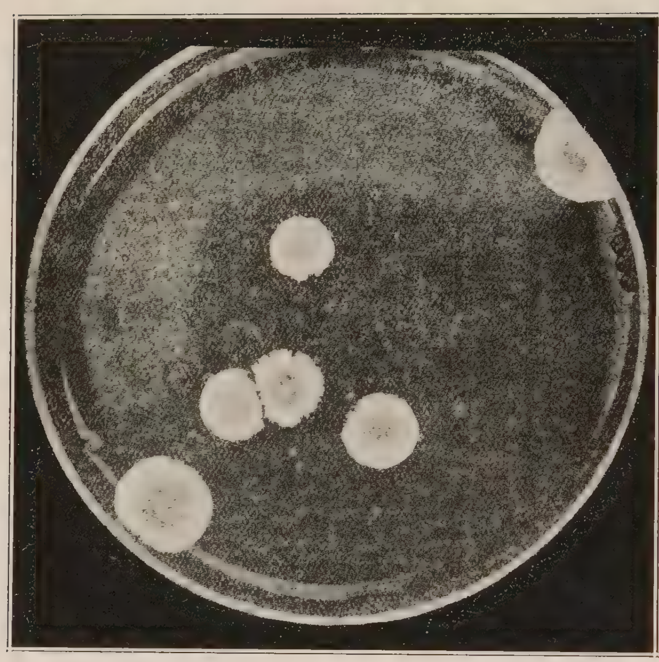


Figure 2. *Aspergillus Fungus*—Growth in Laboratory.

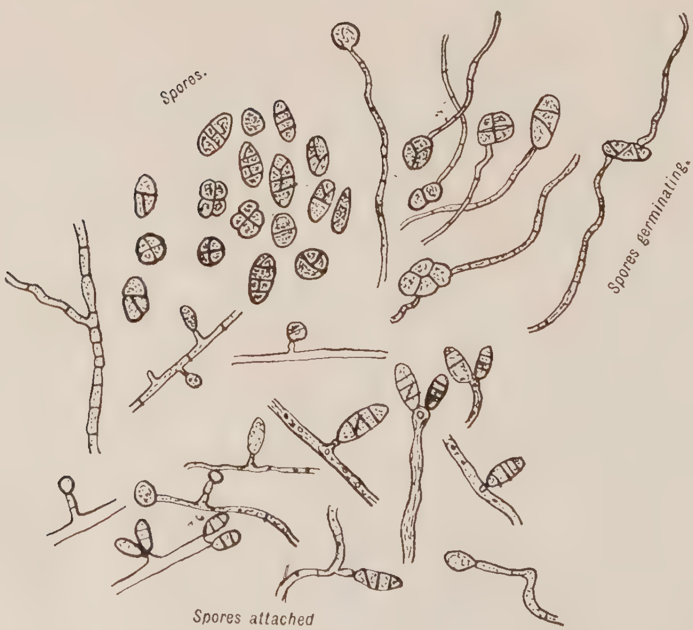


Figure 3. *Stemphylium Fungus* —Illustrations of the

swollen head bear the conidia directly, whereas in *Sterigmatocystis* they bear secondary finger-like processes, and these bear the conidia. The fact that simple and branched finger-like processes may occur in the same fungus is, however, unfavorable to such a distinction being made, and *Sterigmatocystis* is now usually merged in *Aspergillus*. I use the name *Sterigmatocystis* merely to distinguish this fungus from the previously mentioned *Aspergillus*. This fungus is illustrated in figure 4, and in figure 5 are shown the colonies of the fungus grown artificially in the laboratory.

The conidia of this fungus as seen from figure 4 are round, and their outer walls are rough, with minute projections. They are 2.4–3 μ in diameter. The conidial herbage is dark greyish green. To date this fungus has produced only conidial fructifications.

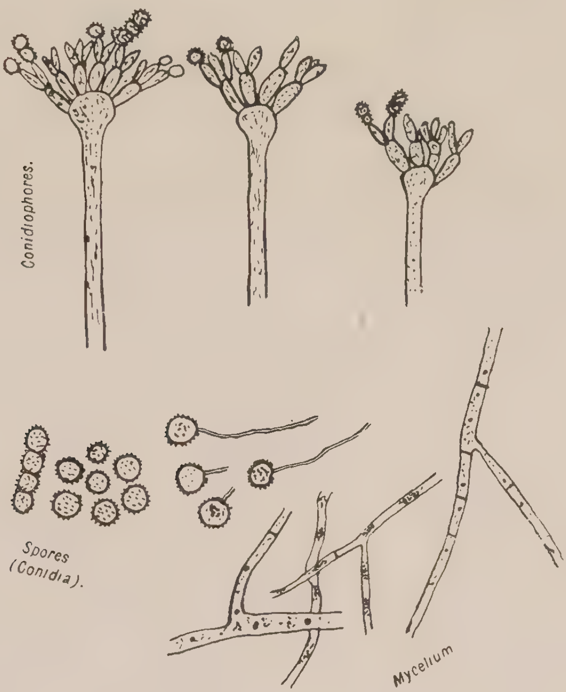


Figure 4. *Sterigmatocystis Fungus*—Illustrations of the.

These few remarks on the nature of the fungi are at present sufficient for our purpose, and I do not wish to overburden the paper with details of little interest to the sugar producer.

(c) Inoculation of Fungi into Liquid Media containing Sucrose.

After the preliminary test for invertase the fungi were grown in media containing sucrose, and these tested to find whether the fungi had inverted the sucrose. The results of analysis are given in Tables I to III.

Figure 5. *Sterigmatocystis Fungus*—Growth in Laboratory.

TABLE I.—DOX SOLUTION:[1] RESULTS OF ANALYSIS FOUR DAYS AFTER INOCULATION.

Fungi.	Invert sugar in 100 c.c.
Aspergillus	1.5
Stemphylium	.47
Sterigmatocystis	1.3
Control	..

TABLE II.—DOX SOLUTION.—RESULTS OF ANALYSIS FOUR DAYS AFTER INOCULATION.

Fungi.	c.c. $\frac{N}{20}$ Caustic Soda to neutralize 20 c.c.	Invert sugar in 100 c.c.
Aspergillus	13.2	.53
Stemphylium	10	.76
Sterigmatocystis	11.8	.8
Aspergillus (*a*)	18	1.8
Control	11	Trace

[1] Sodium nitrate 1, potassium nitrate 1, potassium phosphate .5, magnesium sulphate .01, potassium chloride .01, ferrous sulphate .01, sugar 30, water 1000.

TABLE III.—20° BRIX MILL SUGAR SOLUTION (CLARIFIED WITH ALUMINA CREAM): ANALYSIS FIVE DAYS AFTER INOCULATION.

Fungi.	c.c. $\frac{N}{20}$ Caustic Soda to neutralize 20 c.c.	Invert sugar in 100 c.c.
Aspergillus	1.2	10
Stemphylium	.7	.357
Sterigmatocystis	1	1.26
Aspergillus (*a*)	1.3	15.15
Control	.4	.086

The series of experiments recorded in Tables I–III then left no doubt as to the capability of the fungi to invert sucrose. Table III is remarkable for the high amount recorded under invert sugar for the *Aspergillus* fungus. It is unlikely that all is invert sugar, and most probably the high results are in part due to the presence of other reducing organic substances in addition to invert sugar. That such is probably the case is further indicated by instances where the amount of invert sugar produced was in excess of the cane-sugar started with. Other results of inoculations into mill sugar solutions gave similar high results, and such high results were also obtained with these two fungi when grown in Dunhams solution + sucrose. The difference obtained with the different media probably suggests that the form in which the nitrogenous food is presented may have something to do with it, but it is a matter which I have not yet gone into. Sucrose in solid form offers rather a peculiar medium for the growth of microorganisms, and in addition to the results recorded above it hence appeared desirable to infect some sugar as well.

(d) Infection of Sterilized Sugars.

For this purpose 20 gms. refined sugar were sterilized in previously sterilized flasks. The sugars were then inoculated with the fungi, and, after this, as near as possible the same amount of sterilized distilled water sprayed into each flask. A control flask containing the same quantity of sugar was treated in the same way, except that it was not inoculated. After squirting water on to the sugars, a piece of rubber tubing was tied over the top of the flasks (to prevent evaporation), and the flasks then incubated at 27° C. An analysis made twenty-two days after incubation is given in Table IV.

TABLE IV.

Fungi	Per cent. Moisture	Per cent. Invert Sugar
Aspergillus	2.13	1.3
Stemphylium	2	1.2
Sterigmatocystis	1.8	1.03
Aspergillus (*a*)	2.3	2
Control	1.7	.49

The above then left no doubt that the fungi had inverted the sucrose. To obtain conditions more in accordance with what would take place in storage we next weighed out 10 gms. sugar in previously sterilized flasks. These sugars were, after sterilization, infected with the fungi, but instead of squirting water into them they were covered with a bell-jar, under which was placed a small beaker containing a saturated solution of sugar, to which was added a crystal of mercuric chloride as a disinfectant. The sugars had now to absorb their moisture from their surroundings. The apparatus was incubated at 27° C., and at intervals the flasks were weighed to determine the amount of water absorbed. After twenty-one days the sugars were analysed. In Table V I give the results of this experiment.

TABLE V.

Fungi	Increase in weight in milligrams				Per cent. Invert Sugar after 21 days (on dry weight)
	4 days	7 days	10 days	14 days	
Aspergillus	39	An accident befell this flask in that water dropped on the cottonwool and the weighing of it was hence discontinued.			1.6
Stemphylium	40	110	170	210	1
Sterigmatocystis	57	144	215	277	1.3
Control	30	90	130	161	.73

Here the results again indicate that the fungi have inverted the cane-sugar. The fact that the inoculated sugars absorbed more water [1] than the control I take to be due to the greater hygroscopicity of invert sugar.

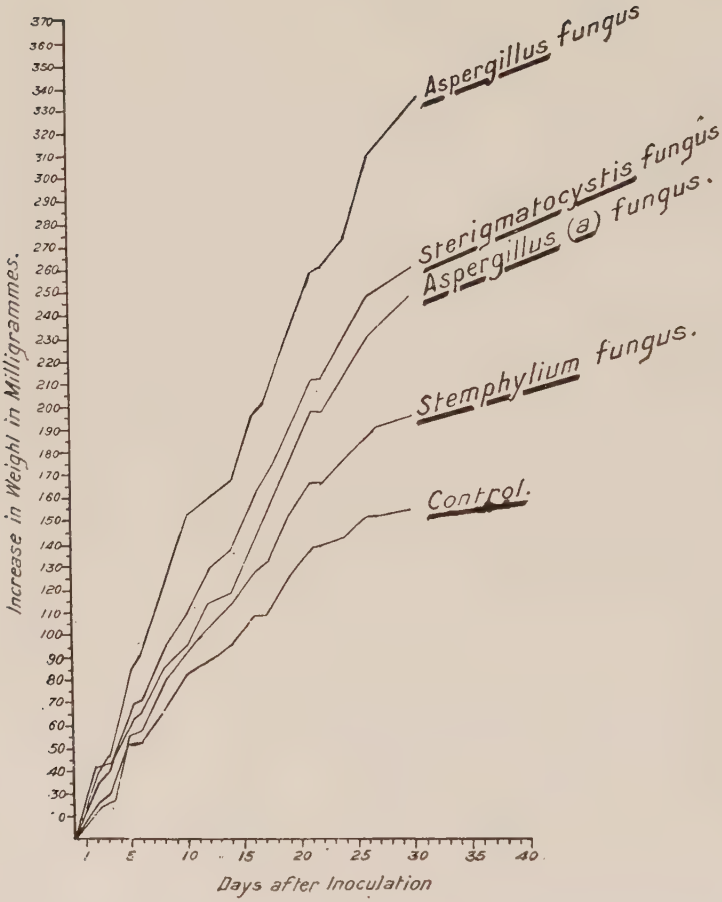
This experiment was repeated, and the results are expressed in Table VI; and in Table VII the increase in weighings is shown graphically:

[1] C. A. Browne (Pl. Rec. XVIII, p. 494-5) points out that a greater water content is present in infected sugars even in sealed containers, the additional moisture in this event apparently being a product of decomposition. W. R. McAllep states that we have data confirming this point.—(C. W. C.)

TABLE VI.

Day after inoculation..	2	3	5	6	8	10	12	14	16	17	19	21	22	24	26	27	30	Per cent. Invert Sugar 30 days after inoculation (dry weight)
	Increase in Weight in Milligramms																	
Control..............	25	28	52	52	67	83	88	95	108	108	125	137	137	141	150	150	152	.215
Aspergillus	41	45	84	90	120	153	159	166	195	199	230	255	258	271	307	312	329	.97
Stemphylium	24	26	56	58	77	91	104	113	127	129	151	165	165	174	186	189	194	.668
Sterigmatocystis	34	38	68	71	93	108	128	137	159	166	188	211	211	228	245	249	258	.85
Aspergillus (a)..........	42	42	62	65	85	95	113	118	141	148	173	196	196	210	227	232	246	.801

TABLE VII.



The last two experiments then show not only that the fungi invert sugar, but also that the infected sugars take up more moisture from their surroundings, and the fungi hence have some bearing on the process popularly called "sweating." To prevent any misunderstanding I would, however, mention at once that "sweating" may result without any micro-organisms being present, due it is held to adhering films of molasses and brought about by improper conditions of storage. The "sweating" of a sterile sugar would, however, not be accompanied by deterioration such as we record.

(e) Growth in Sugar Solutions of Different Densities.

Sugar in solid form appears a peculiar medium to micro-organisms. We would, for example, expect micro-organisms living on it to be capable of withstanding high concentrations of the medium, and the natural medium being poor in albuminoids we would expect the germs living on it to have low nutritive requirements. The second requirement necessary to these germs we have seen fulfilled by the inoculation of sterilized sugars. To test the concentrations of

sugar in which the fungi are capable of growing mill sugar solutions of different degrees Brix were prepared. The solutions were tubed, and after sterilization inoculated with the fungi and incubated.

With the exception of *Stemphylium* all the fungi grew in solutions of 63° Brix concentrations. *Stemphylium* grew in concentrations of 58.7° Brix, but not in 63° Brix, the highest concentration tested.

(f) Resistance of the Fungi to Heat.

None of the fungi are very resistant to heat, as was shown by placing tubes of sugar solutions inoculated with them in boiling water for different periods. Fifteen minutes' (the shortest period tested) immersion was sufficient to kill them all.

They would hence not withstand the temperatures met with in sugar factories, and the results would further suggest that for them steam would be both a cheap and an efficient method of disinfection.

Though the fungi easily succumb to the temperature of boiling water their economic importance is in no way diminished, as infection may take place afresh at different stages in the manufacture of sugar, depending, of course, on the sources of infection and the liability of the particular sugar to deterioration.

(g) Tests Against Various Disinfectants.

The fungi were tested against various disinfectants, and we selected for our experiments those which are used, or have been recommended, either in the sugar or allied industries. Those tested were: Formalin, chloride of lime, bisulphite of soda, lime-water, sodium fluoride. The details and results are given under each.

Flourides.

Hydroflouric acid and certain of its salts have a powerful germicidal action. A 5 per cent solution of ammonium flouride is recommended by Jorgensen for cleaning vats in distilleries and breweries. It has also been recommended in the beet sugar industry as an excellent means of combating *Leuconostoc mesenteroides*. Harloff recommends a 1 per cent solution of sodium flouride as a sugar factory germicide, and especially for cleaning the rollers as well as for general germicidal purposes.

We tested our fungi against sodium flouride and ammonium flouride as follows: To 50 c.c. of mill sugar solution in small flasks were added the quantities stated in the tables below. The flasks were then sterilized, and after sterilization inoculated with the fungi and incubated.

The results are given in Tables VIII–IX, where

$+ =$ growth
$- =$ no growth.

TABLE VIII.—GRAPHICAL REPRESENTATION OF THE INCREASE IN MOISTURE ABSORPTION IN SUGARS INFECTED WITH THE FUNGI.

TABLE VIII.—SODIUM FLUORIDE.

Fungi	Grammes added to 50 c.c. mill sugar solution				
	.1	.2	.25	.27	.3
Aspergillus	+	—	—	—	—
Stemphylium	+	—	—	—	—
Sterigmatocystis	+	+	+	—	—
Aspergillus (a)	+	—	—	—	—

TABLE IX.—AMMONIUM FLOURIDE.

Fungi	Grammes added to 50 c.c. mill sugar solution					
	.1	.2	.25	.3	.5	1
Aspergillus	+	+	....	+	—	—
Stemphylium	+	....	+	—	—	—
Sterigmatocystis	+	+	+	+	—	—
Aspergillus (a)	+	+	+	+	—	—

Bisulphites.

Jorgensen recommends both sodium bisulphite and calcium bisulphite for use in breweries and distilleries, and both these substances have also been recommended as germicides for sugar factories.

We experimented with sodium bisulphite as follows: 50 c.c. mill sugar solution were sterilized in flasks, and after sterilization different quantities of a 5 per cent solution of sodium bisulphite added. The flasks were then inoculated and incubated, and the results are given in Table X, where:

+ = growth

— = no growth.

TABLE X.—BISULPHITE OF SODA.

Fungi	c.c. 5 per cent. Sodium Bisulphite added to 50 c.c. mill sugar solution					
	.2	.5	1	1.5	2	4
Aspergillus	+	—	—	—	—	—
Stemphylium	+	+	+	+	+	—
Sterigmatocystis	+	+	—	—	—	—
Aspergillus (a)	+	—	—	—	—	—

Formalin.

Jorgensen recommends the use of formaldehyde in 5 per cent strengths for cleaning vats in breweries and distilleries.

In the beet sugar industry it has been recommended to prevent fermentation in the diffusion batteries. In the sugar industry as a whole formalin is

generally employed for the preservation of laboratory samples, and Spencer recommends for this purpose 3 c.c. of formalin to a cubic foot of juice clarified by the sulphur process, and 6–8 c.c. to a cubic foot of juice clarified by the ordinary process.

Simpson, in 1908, advocated the addition of formalin solution to all juice from the cane, and claimed that, in addition to destroying organisms which cause deterioration, it aided in the purification by eliminating albumins and pectins. He recommended a 2 per cent water solution of formaldehyde to the raw juice at the first mill, in the proportion of one part of the solution to 1000 parts of juice. This is approximately equivalent to 1 part of 40 per cent commercial formalin to 20,000 parts of juice.

To my knowledge the above suggestion of Simpson has not found acceptance, and I can find no reference stating that formalin is employed, as he suggested.

Owen concludes that formaldehyde is superior to any germicide for disinfecting syrup tanks or removing micro-organisms, which cause deterioration of sugar.

Norris reported on changes in the polarization of sugar solutions brought about by the addition of formalin, and he holds that an unstable compound is formed between these two substances, and that this has a higher polarization than sugar itself. He further shows that in the proportion of 1 part or less of formalin to 100 of mill juice the polarization is not affected, and that concentrated sugar solutions have their polarizations raised by smaller quantities of formalin than weaker solutions. Upon diluting such concentrated solutions the increase in polarization disappears.

Numerous experimenters with different fungi and bacteria record that 1:10,000 to 1:20,000 of formaldehyde generally suffices to render the organisms sterile, but that it takes at least 1:1000 to kill them.

For testing formalin on our fungi, various quantities of a .5 per cent solution of commercial formalin was added to 50 c.c. of sterilized mill sugar solution, and the mixtures then inoculated with the fungi and incubated. The results are given in Table XI, where "+" indicates growth and "—" no growth.

TABLE XI.—FORMALIN.

Fungi	c.c. of .5 per cent. solution of commercial Formalin added to 50 c.c. of mill sugar solution							
	2	4	5	7	8	9	10	12
Aspergillus	+	+	+	+	+	+	+	—
Stemphylium	+	+	+	+	+	—	—	—
Sterigmatocystis	+	+	+	+	—	—	—	—

The above table is based on observations taken at intervals for seven days. It is probable that during this period a certain amount of the formalin may have evaporated, and the fungi not having been killed, but only retarded, continued their growth. Also, as every sugar chemist knows, a certain quantity of the disinfectant may inhibit the growth of germs in his juices for a certain period

only, and if he wishes to preserve his juices for a longer period he has to add a larger quantity of the disinfectant. It was noted that 4.5 c.c. of the formalin solution inhibited the growth of all the fungi for two days. This works out roughly to 1 pint of commercial formalin solution in 2300.

Chloride of Lime (Bleaching Powder).

This substance has been recommended in breweries for the disinfection of filter-bags, and finds a similar use in sugar factories.

Owen concluded that in cases where the germicide involved any great penetrating power, as, for example, where gums are to be removed, and in cleaning tanks which contained fermented juices, this substance is more economical than formalin. Will, who experimented with material obtained from a brewery, recommends a solution containing 1 per cent available chlorine.

In our experiments below, 2 grammes of the chloride of lime were dissolved in 100 c.c. water, well shaken, and the sediment allowed to settle. Varying quantities of the supernatant liquid were then added to 50 c.c. mill sugar solution in flasks; the flasks infected with the fungi were incubated.

As the amount of available chlorine varies considerably in different samples, it was thought desirable to determine it for the material used, and it was found to contain only 16 per cent of available chlorine, which is very low.

In Table XII below are given the results with chloride of lime:

+ = growth
— = no growth.

TABLE XII.—CHLORIDE OF LIME.

Fungi	c.c. of 2 per cent. Chloride of Lime, having 16 per cent. available Chlorine, added to 50 c.c. sterilized mill sugar solution								
	.2	.5	1	1.5	2	3	4	5	6
Aspergillus	+	+	+	+	+	+	+	+	—
Stemphylium	+	+	+	+	+	+	—	—	—
Sterigmatocystis ..	+	+	+	+	—	—	—	—	—
Aspergillus (a)....	+	+	+	+	+	+	+	—	—

In the sugar solution, to which 6 c.c. of the chloride of lime were added and in which none of the fungi grew, there was approximately .03 per cent of available chlorine.

Milk of Lime.

Jorgensen recommends fresh milk of lime as a disinfectant for the walls and ceilings of breweries and distilleries. It is employed in the sugar industry for cleaning the rollers and for general germicidal purposes. As is well known this substance is inefficient in preventing the growth of *Leuconostoc mesenteroides,* which growth is at times so bad in factories as to cause the blocking up of the pipes. This inefficiency may possibly be due to the fact that this organism favors a neutral or slightly alkaline solution.

Quicklime, being always on hand in sugar factories, makes milk of lime a

particularly suitable factory germicide, and Owen recommends it as more economical than formalin for cleaning vats containing fermented juices. We used a milk of lime solution containing 5 per cent CaO and noted that even when 5 c.c. of this solution was added to 50 c.c. of sugar solution there was no growth. Allowing the sediment to settle and using only the clear supernatant fluid, even the addition of 20 c.c. to 50 c.c. of mill sugar solution did not prevent the growth of these fungi. We believe the difference is in large part probably due to the fact that in using milk of lime the fungus is carried to the bottom with the lime particles as these subside.

An Additional Fungus.

While the work on the fungi reported was nearing completion, another was obtained, and it was thought desirable to just embody the few results about it in this paper. This fungus is *Hormodendron cladosporoides.* The spores are colored and their method of formation is illustrated in figure 6.

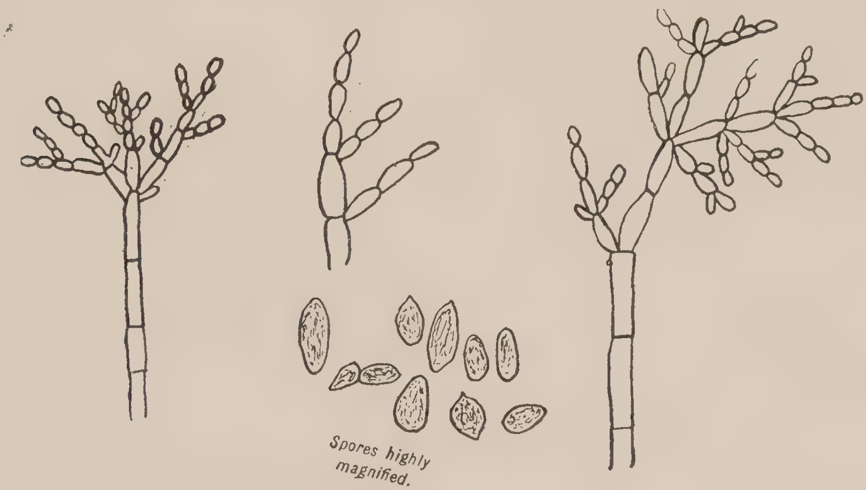


Figure 6. *Hormodendron Fungus*—Illustrations of the.

Action on Media Containing Sucrose.

TABLE XIII.—DOX'S SOLUTIONS, FOUR AND ELEVEN DAYS AFTER INOCULATION.

	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.
Control	8.7	.09
Inoculated .... I —4 days	12.3	.14
" ....II —4 days	10.4	.46
" ...III —11 days	15	1.7

TABLE XIV.—MILL SUGAR SOLUTION, FOUR DAYS AFTER INOCULATION.

	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.
Control........	1.5	.25
Inoculated..... I........................	1.2	.78
" .... II........................	1.15	.9

Part II—Bacteria.

I believe Dobson (1902) was the first who investigated bacteria in connection with the deterioration of sugars. His publication, "Relation of Bacteria to the Inversion of Crystallized Sugars," was not available to me. At about the same time as Shorey published on the fungus *Penicillum glaucum,* Greig Smith published an article entitled "The Deterioration of Raw and Refined Sugar Crystals in Bulk." In this article he attributed the deterioration to a bacterial organism which he named *Bacillus levaniformis.* The second name refers to the property of this bacillus for forming the gum levan from sugar. Greig Smith at the same time pointed out the similarity between his organism and the group of bacteria known as the "Potato Bacilli." In a few words the most striking features of this group can be given as:

(1) The high resistance of their spores to heat.

(2) Their capacity of forming gum in the fermentation of sugars.

(3) Their low nutritive requirements.

Lewton-Brain and Noel Deer deal with five gum-forming bacteria isolated from sugars. Owen, in extending the investigations on sugar bacteria, compared them with members of the potato group and also showed that members of this group isolated from sources other than sugar products can acquire the property of destroying sugar.

The three bacterial organisms from sugar which we have thus far worked on belong to the potato group of bacilli. That they are all three closely related is shown by their cultural, morphological, and physiological characters.[1]

*　　*　　*　　*　　*　　*　　*

Bacillus I and Bacillus II are nearest to *Bacillus vulgatus* and Bacillus III to *Bacillus gummosus.*

We have thus far not made any systematic survey of the micro-organisms occurring in the mills, but have incidentally obtained an organism belonging to the same group of bacteria from juice at the first roller.

Inoculation of Media containing Cane-sugar with the three Bacterial Organisms and Subsequent Determination of Invert Sugar in the Media.

(a) [2] Dunham's solution + 10 per cent sucrose. Analysis three days after infection is given in Table XVII.

[1] Tables XV and XVI of cultural, morphological, and biochemical featurs of the three bacteria are omitted.

[2] Peptone 1, Sodium Chloride .5, Sugar 10, Water 100.

TABLE XVII.

	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.
Control	1.8	.06
Bacillus I	2.95	1.25
Bacillus I	3	1.5
Bacillus II	3.3	2.4
Bacillus III	3	1.7
Bacillus III	3.1	1.7

(b) Mill sugar solution 20° (Brix), three and seven days after inoculation.

TABLE XVIII.

	3 days after infection		7 days after infection	
	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert Sugar in 100 c.c.
Control	1.5	.25	—	—
Bacillus I	1.35	1.7	1.8	3.3
Bacillsu II	1.6	2.6	1.7	3.7
Bacillus III	1.4	.33	1.7	.43

These experiments show the three bacterial organisms capable of inverting sucrose.

Formation of Gum.

They were next again grown in 20° Brix mill sugar solution, and this tested to find if there was an increase in ash-free alcoholic precipitate.

TABLE XIX.—ASH-FREE ALCOHOLIC PRECIPITATE PER 100 C.C., EIGHT DAYS AFTER INOCULATION.

	Ash-free Alcoholic Precipitate per 100 c.c.—8 days after inoculation.
Control	.03
Bacillus I	.72
Bacillsu II	.17
Bacillus III	.08

The amount of ash-free alcohol precipitate formed by these bacterial organisms in 20° Brix raw mill sugar solution differed considerably in different experiments. Below I give the result obtained in an experiment, using the same sugar as was used above:

TABLE XX.—ASH-FREE ALCOHOLIC PRECIPITATE PER 100 C.C., TWELVE DAYS AFTER INOCULATION.

	Ash-free Alcoholic Precipitate per 100 c.c.—12 days after inoculation.
Control	.03
Bacillus I	.096
Bacillus II	.42
Bacillus III	.11

These experiments hence show that in addition to inverting sugar one of the products formed by these micro-organisms is gum.

Resistance of the Spores of the Bacteria to Heat.

The spores of bacteria are usually very resistant to heat, and we have noted that this applies specially to the potato group of bacilli.

To test their resistance to heat, tubes of sugar solution were infected from old cultures. These tubes were placed in boiling water, and at intervals plates were poured from them.

In Table XXI below I give the results obtained: + indicates that growth took place; — indicates that there was no growth, i.e. the spores were killed.

TABLE XXI.

Time of Exposture	15 Minutes	30 Minutes	1 Hour	2 Hours
Bacillus I	+	+	+	—
Bacillus II	+	+	+	—
Bacillus III	+	+	+	+

The spores of the bacteria are, as is evident from the table above, highly resistant, and survived the temperature of 100° C. (212° F.)—in cases even for as long as two hours.

Tests with Various Disinfectants.

The disinfectants tested were those mentioned when dealing with fungi.

We used a different method and proceeded as follows: To test their antiseptic property on the bacteria, i.e. the strength in which they prevented the growth of the bacteria, solutions of them were made up double the strength it was desired to test. When 5 c.c. of these solutions were added to 5 c.c. of sugar agar tubes, it gave the desired strength. The sugar agar was melted up and the disinfectants added just before setting. The tubes were well shaken and then slanted, and when the agar had solidified they were inoculated with the bacteria. To test the germicidal properties the 5 c.c. of the disinfectants of different strengths were added to 5 c.c. of sterilized mill sugar solution. Into these tubes were then pipetted .1 c.c. of a fresh culture. The inoculated tubes were then incubated at 30° C. for 30 minutes, after which time plates were poured from them in order to find whether the bacteria had been killed. The cultures used for testing the antiseptic and germicidal properties of the

different disinfectants were in every instance less than 24 hours old. The results obtained are given in the tables below.

+ indicates the strengths of the disinfectants found to be antiseptic or germicidal, respectively.

— indicates that in these strengths the disinfectants were not antiseptic or germicidal.

TABLE XXII.—FORMALIN—ANTISEPTIC PROPERTIES OF COMMERCIAL FORMALIN.

Strengths	1 : 10,000	1 : 5,000	1 : 2,500
Bacillus I....................	—	+	+
Bacillus II....................	+	+	+
Bacillus III....................	+	+	+

In the proportion of 1:5000 the commercial formalin is hence antiseptic to all the bacteria experimented with.

The germicidal properties of this substance were tested only against Bacillus I and II, and it was found that even 1:50 of commercial formalin did not kill these bacteria in the 30-minutes' exposure.

The use of formalin in mills is, however, primarily as an antiseptic.

TABLE XXIII.—SODIUM FLUORIDE—ANTISEPTIC PROPERTIES.

Strengths	.031 per cent.	.062 per cent.	.125 per cent.	.25 per cent.	.5 per cent.
Bacillus I.............	—	—	—	+	+
Bacillus II.............	—	—	—	+	+
Bacillus III.............	—	—	—	+	+

The germicidal properties of this substance were tested against Bacillus I and II, and it was found that a 30-minutes' exposure to a 1 per cent solution did not prove germicidal.

TABLE XXIV (A) AND (B).—BISULPHIDE OF SODA.

(a) Antiseptic Properties.

Strengths	.015 per cent.	.031 per cent.	.062 per cent.	.125 per cent.
Bacillus I.............	—	+	+	+
Bacillus II.............	—	—	+	+
Bacillus III.............	—	—	+	+

(b) Germicidal Properties.

Strengths	.125 per cent.	.25 per cent.	1 per cent.	2 per cent.	4 per cent.
Bacillus I.............	—	—	—	+	+
Bacillus II.............	—	—	—	+	+
Bacillus III.............	—	—	—	+	+

TABLE XXV.—CHLORIDE OF LIME—GERMICIDAL PROPERTIES.

Strengths	.25 per cent.	1 per cent.	2 per cent.
Bacillus I....................	—	—	+
Bacillus II....................	—	—	+
Bacillus III....................	—	+	+

The chloride of lime experimented with contained 21.3 per cent available chlorine, so that in the 2 per cent solution tested there was approximately .4% of available chlorine.

Part III—General Considerations.

In the foregoing pages we have noted some of the organisms responsible for the deterioration of sugars and the nature of the changes which they induce.

We cannot dismiss the subject without drawing attention to some of the views of other investigators and noting certain factors which would influence the liability of deterioration of sugars by micro-organisms. Amongst these we mention

Moisture Content.

Moisture is essential to the growth of all micro-organisms. Lewton-Brain and Norris claim that no deterioration can take place in a sugar containing less than 1 per cent moisture. With this Owen agrees and points out that the validity of the "factor of safety" $\frac{\text{water}}{(100 - \text{pol.})} = .333$ decreases as we depart from a film of natural molasses around the crystals and deal with washed sugars, i.e. washing the sugar increases its purity and hence the ratio of $\frac{\text{moisture}}{\text{solids non-sucrose}}$ is increased, or in other words the density of the molasses film around the crystals is decreased, and the sugar becomes more liable to deterioration. Owen writes: "Evidently one of the surest means of manufacturing raw sugars which will not deteriorate in storage is to keep the density of the molasses films surrounding their crystals beyond 75 Brix. This applies, of course, only to raw sugars, as the keeping quality of white sugar must, in the nature of the case, depend upon its absolute dryness. But to manufacture sugars with a polarization of 96, with films of very low purity molasses necessitates a thorough purging of the crystals, so that they will retain only a small amount of molasses, otherwise the polarization of the sugar would be too low. However, a good purging can only result from good and effective clarification, and it is to the deficiency in this respect that much of the trouble from deterioration is due. If the massecuite is viscous from excess of lime it does not purge well and excessive amounts of water have to be used in the centrifugals."

This suggestion of Owen is, of course, based on the fact that in a molasses film of high density micro-organisms cannot grow. A sugar having the required "factor of safety" can, of course, become unsafe through the absorption of moisture from the atmosphere by which the ratio $\frac{\text{water}}{\text{solids non-sucrose}}$ would be

increased, or we may regard it as the film of molasses being diluted and the growth of micro-organisms made possible. For the same reason the factor of safety becomes less reliable in high-grade washed sugars as the molasses film is diluted, and in white sugars the total moisture present is the only criterion of safety, since the density of the film cannot be high enough to prevent the growth of micro-organisms. These considerations of Owen appear quite sound and plausible.

The next is the absorption of moisture by sugars in storage, which moisture enables the micro-organisms to grow and deteriorate the sugar. Studying a chart of the relative humidity and temperature at Durban during the year, those who handle sugar will at once perceive that the periods when they are most troubled by "sweating" and deterioration are during the months when the relative humidity and temperature are highest. . . . . . .

Temperature.

Next to moisture the most important factor in sugar deterioration is probably the temperature. It has been suggested that cool storage should be combined with dry storage. In this connection Owen cites the following suggestive and interesting experiment: Samples containing sufficient moisture to enable them to deteriorate were placed respectively in (1) a refrigerator at approximately 20° C., (2) in an incubator at 34° C., (3) left at room temperature. In every instance the refrigerator sample deteriorated slightly as compared with the others. These results are, of course, based on the fact that the lower temperatures retarded the growth of the organisms. In Table XXVI below we give results obtained in Dox's solution, inoculated with our Sterigmatocystis fungus and incubated at (1) 30° C., (2) room temperature, (3) ice chest.

TABLE XXVI.—ANALYSIS FOUR DAYS AFTER INOCULATION.

	c.c. Caustic Soda $\frac{N}{20}$ to neutralize 20 c.c.	Invert sugar in 100 c.c.
Control	.1	—
30° C.	.45	1.5
Room temperature (19°—23° C.)	—	.1
Ice-chest (11°—15° C.)	No evident growth of fungus and analysis similar to control.	

Earlier in this paper we have noted the resistance to heat which the different organisms show. The fungi we note are readily killed by the temperature of boiling water, whereas the bacteria are very resistant. Fortunately we now know that bacteria are not the main causes in sugar deterioration. They appear to exert an action on crystal sugar only when the moisture content is abnormally high, and further they cannot thrive in such high densities as the fungi. The main agents in sugar deterioration—the fungi—readily succumbing to heat may suggest the sterilization of sugars, but even when sterilized subsequent infection would still have to be guarded against.

I believe they are in Louisiana at present studying the possibility of actually

sterilizing the sugar and washings in the centrifugals by means of super-heated steam. It is also primarily from this viewpoint that previous workers have suggested the substitution of water by steam at the centrifugals.

Kammerling has suggested that deterioration of sugars is produced by micro-organisms introduced from the bags and recommended their disinfection in a 1 per cent solution of carbolic acid. Results in Prinsen Geerlig's "Cane-sugar and Its Manufacture," however, show that no benefit is derived from such disinfection, probably because the sugars may carry the germs causing deterioration before being bagged. It should, however, be mentioned that the fungoid threads offer an easy means for penetrating the bags and especially if they should come in contact with material containing the germs. This should suggest that the storehouses should be kept scrupulously clean and all filth (may be slimy masses of fermented sugar, etc.) removed, and that the floors and walls of the building may possibly be disinfected.

Contaminated wash water has been held as a source of infection of sugars, and Noel Deer observed an instance where the deterioration was due to the cooling-tower water used in washing at the centrifugals. Browne regards the cooling-tower water as the most dangerous source of infection. As he points out, it contains sugar lost by entrainment, and is very favorable for the growth of micro-organisms. He further writes that the spray from the cooling-tower is carried into the factory, where it comes into contact with bags and sugars. Attention has been called to the possible infection of sugar through bagasse particles which find their way into raw sugars. This was more fully investigated by Owen, and his conclusion is that these particles only influence deterioration by the absorption and retention of moisture, thus creating moist zones in which deterioration can take place. He does not attach much importance to the view that the bagasse particles carry the germs, and holds that the most dangerous infection of sugars takes place in the centrifugals. He recommends the use of covered centrifugals.

It is the general opinion that in mills the infection takes place chiefly at the centrifugals, and this may in some measure be due to the air sucked through with the rapid revolving of this machine, as has been suggested. Probably covering the sugar conveyances to the centrifugals, and also from the centrifugals, would also remove some sources of infection.

Generally speaking, more and more stress is being laid upon the importance of cleanliness in the factory as a preventive in the deterioration of mill sugar. It is thought that the experiments with antiseptics recorded in this paper may be of some value in this connection.

From reports it would appear that in Hawaii losses from sugar deterioration have been almost eliminated, and there the correction of this trouble is generally believed to be due to the improved cleanliness in the factory.

It would to the writer appear wrong to attach too great importance to any one particular source of infection. Recognizing that the molds responsible for sugar deterioration are common ones and by no means limited to sugar only, it would appear that after the sugar leaves the pans it should be handled under conditions as hygienic as possible, whether these conditions involve the periodical disinfection of floors, etc., in the mills, the disinfection of mills in the off-season

or any other precaution. Similarly in storage, the conditions should be hygienic and as far as practicable tend to keep the sugar dry and cool and prevent moisture absorption during unfavorable weather conditions.

In our experiments with the various disinfectants we do not necessarily mean to suggest that they are all equally suitable for use in factories, etc. Among the main considerations should be their cheapness and whether they are easily procurable. Formalin, chloride of lime and milk of lime appear to be the three most suitable. Milk of lime should be useful for disinfecting the walls and ceilings of storehouses, etc., and cleaning the tanks. Chloride of lime has a high germicidal power, and should be specially useful for disinfecting filter bags and tanks containing fermented juices. It remains only to mention that these disinfectants are more efficient at higher temperatures and are hence in the disinfection of sugar factories preferably used hot.

Natal Herbarium, Berea, Durban, September, 1919.

[C. W. C.]

SUGAR PRICES FOR THE MONTH

Ended October 15, 1921.

		96° Centrifugals		Beets	
		Per Lb.	Per Ton.	Per. Lb.	Per Ton.
	(Sept. 16, 1921)	4.00c	$ 80.00		
	" 22	4.3125	86.25	No quotation.	
	" 23	4.50	90.00		
	" 27	4.21625	84.325		
[1]	" 28	4.125	82.50		
[2]	" 29	4.205	84.10		
[3]	" 30	4.1175	82.35		
	Oct. 3	4.2133	84.266		
	" 6	4.23	84.60		
	" 10	4.125	82.50		
	" 11	4.23	84.60		
[4]	" 14	4.11	82.20		

[1] Domestic.

[2] Cubas 4.11. Export 4.30.

[3] Cubas 4.11. Domestic 4.125.

[4] Cubas.